THE *Petroleum* Engineer **Management Edition**

Exploration—Drilling—Producing • Refining—Petrochemical—Gas Processing • Oil and Gas Pipelining

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That Startling Happening in Texas

A somewhat unusual, and in a sense startling, thing happened down in Texas a few days ago. The Texas Independent Producers and Royalty Owners Association, at its annual meeting, made an Award of Merit to the Standard Oil Development Company for completion within the last year of the Fluid Coking Process. This recognition of a major oil company affiliate by a group of independents, is unexpected enough to justify comment because by the nature of things these groups sometimes have interests that do not parallel each other.

What is this Fluid Coking Process and why is it of so great a benefit to independent producers, among others? What is a coking process, as a matter of fact, of which others are known and used by the industry?

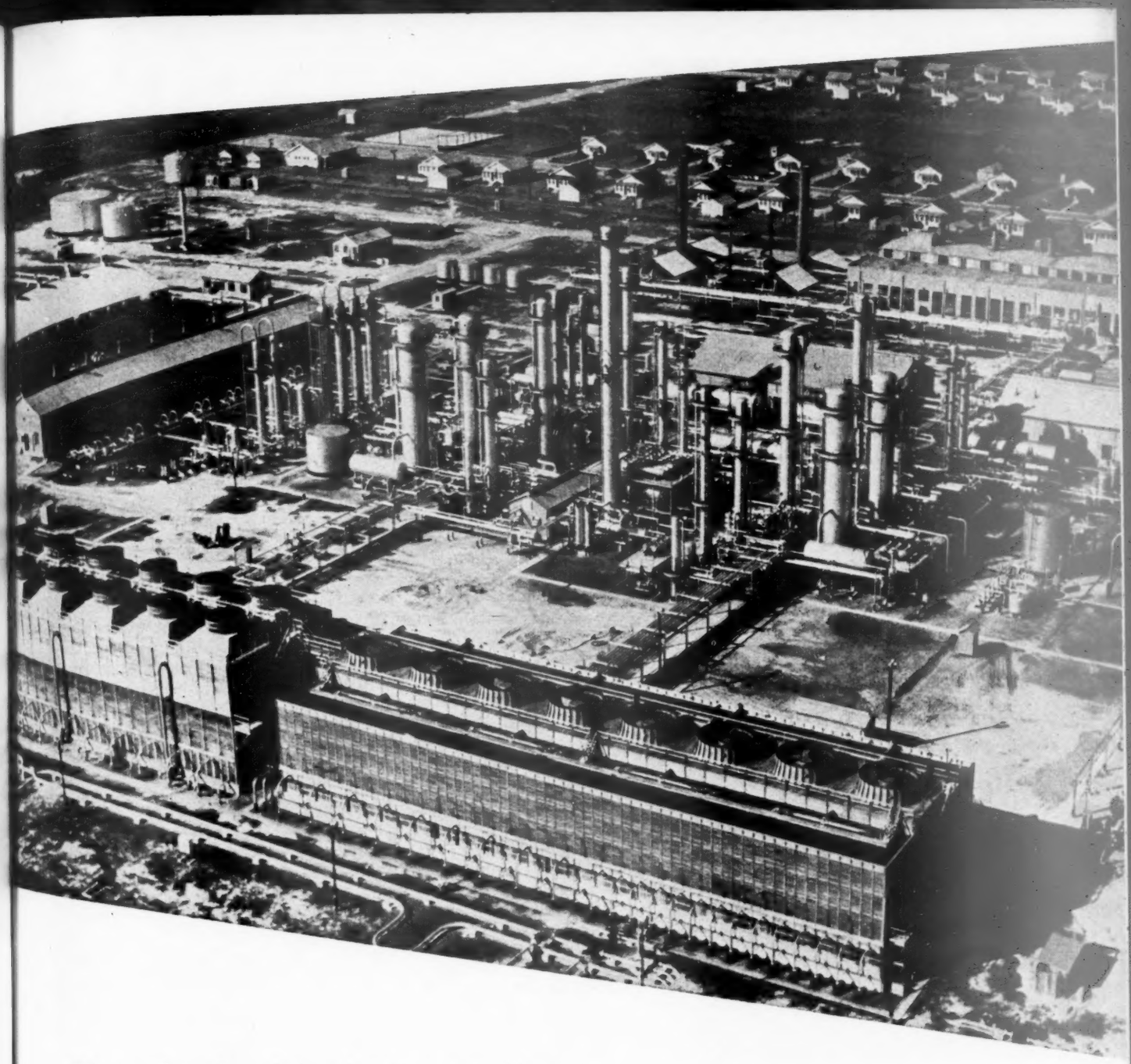
A most significant fact of this new process is that it can utilize as raw material extremely low grade crude oils and crude oil residues. Prior to development of the process these stocks were difficult to upgrade and, in some instances, could not be upgraded economically. Process is based on what is known as "fluidized solids" refinery technique, in which a fluid-like stream of hot, fine particles of coke provides the heat and surface area required to vaporize and convert the heavy residual parts of crude oil.

Resulting products are gasoline, heating oil, chemical intermediates, gas of high Btu content, and a different type of coke. The coke itself has value as a fuel but a far greater value in the processing of steel and aluminum, as well as in other fields not yet fully delved into. In fact, those who are completely familiar with the many possibilities are sufficiently enthusiastic to visualize a day when products made from petroleum may be so much more valuable than gasoline and oil that atomic energy or some other power for propelling vehicles will be welcomed and sought. If this happens such problems as overproduction and excessive imports will be solved automatically.

Although not a new product, petroleum coke heretofore has been so expensive to produce that its use has been restricted. Fluid coking reduces the cost of manufacture to such a level that it can be utilized fully for purposes where it has known value, such as metallurgy, and for many others that undoubtedly will be developed rapidly. Its fixed carbon content of 90 to 95 per cent and its high degree of purity are reasons for the extensive use in metallurgical processing, but scientists say there are literally thousands of other potential uses for coke that have never been fully explored.

TIPRO members have a personal interest in this development because it will mean a greater demand for all petroleum, and especially for the heavier crudes. It will mean money in their pockets, and is thus a boon to the independent producer. This viewpoint alone might be justification enough for bestowing its very first Award of Merit on Standard Oil Development. But that was not the sole consideration nor even the major one. In the Fluid Coking Process is seen a development that well could open up a new era for the oil industry. That is the basic consideration that prompted the award. The action reflects also a common aim of all segments to benefit the industry and humanity as a whole, as well as a proper appreciation one for the other whether they be classified as "majors" or "independents."

— F. H. L.



This recycling plant, designed and constructed by Stearns-Roger, is the largest gas processing plant in the industry and is owned by 33 separate interests, including many major companies.

It processes well over 500 million cu. ft. of gas per day. Absorbers operate at 1800 p.s.i. and treated gas is recompressed to 3500 p.s.i. for return to producing formations. Much of the equipment, manufactured in our Denver shops, was limited in size only by railroad weight and clearance limits to the plant site.

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HIGHLIGHTS

★ ★ ★

Digest of News and Comment

Iran Oil Solution

Although the Zahedi government in Iran is eager to settle its three-year-old oil problem, a solution will not come easy it is believed. Eight oil companies meeting in Iran have worked out arrangement for producing and marketing oil. Arrangement would: Provide for foreign supervision of oil fields and refineries; split marketing up among the eight companies; pay oil royalties to Iran, but not the $100,000,000 Iran wants to run its government; keep Iranian output down to normal increase in demand in Eastern Hemisphere.

★ ★ ★

D & D Seminar

Second Desk and Derrick Seminar is being held at Tulsa University, June 5 and 6. Subjects chosen as a result of requests from 294 out-tof-town members, include: Conservation, economics, employee relations, oil and gas law, secondary recovery, and well logging. Program was developed by Desk and Derrick seminar committee with Dean M. M. Hargrove, A. L. Springfield, and John Hayes of the university.

★ ★ ★

Antitrust Suit Victory

Texas has won a major victory in its 5-year-attempt to collect antitrust penalties from 10 gasoline marketers. Third court of civil appeals at Austin ruled that charges by Price Daniel, attorney general, and his successor, John Ben Shepherd, are worthy of trial. Lawsuit had been dismissed by District Judge Charles O. Betts. The state, which is seeking penalties totaling $14,000,000, contend price rises made after price controls ended were result of conspiracy. Defendants claim general business conditions prompted increases.

★ ★ ★

Phillips' Case Arguments

Hearings before the Supreme Court on whether Phillips sales of natural gas to interstate pipe lines are subject to Federal Power Commission control, have not at this time brought a decision. In the heated argument before the Senate group, Justice Black and Chief Justice Warren asked why Congress passed the Kerr Bill, if, as it had been implied by Phillips' lawyer, Hugh Cox, legislative history showed Congress had never intended to regulate sales by producers and gatherers.

Argument was presented that producers get too much for their gas, whereupon it was pointed out that housewives pay $1.20-$1.40 for gas that producers in Texas are paid 5 to 10¢ for.

★ ★ ★

Future Oil Plans

U. S. oil industry will spend more than $4.6 billion in 1954 to expand and develop its resources and facilities to meet heavy demands of the present and future, President Frank M. Porter reported to the API board of directors. He said this is greatest single sum of money ever earmarked for such purpose in any one year of petroleum history. He added only a little more than $6 million is scheduled for foreign use, with balance for development in the U. S.

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Mexico Seeks Gas Market

Increased use of its natural gas is in Mexico's oil plans of the future, Antonio Bermudez, head of the government Pemex company, reports. Gas reserves are equivalent to 635,000,000 bbl of oil, and more than the country requires, so possibilities of exporting it will be studied. Mexico's total oil reserves are 2,297 million barrels. Production is about 86,000,000 bbl of oil per year.

★ ★ ★

Texas Oil Flow Cut

Texas is producing less oil this month, after Texas Railroad Commission cut 192,915 bbl from the daily oil quota. New permissible production is 2,903,341 bbl per day, with a 17-day schedule generally observed.

Louisiana oil allowables were cut 5 per cent this month, to around 661,000 bbl by that state's Conservation Commission.

★ ★ ★

New Tidelands Bill

Department reports from the Justice, Interior, Welfare, Navy, and Budget Bureaus have been requested on a new Tidelands bill now with Senate Interior Committee. The bill, was sponsored by Senators Hennings (D. Missouri) and Douglas (D. Illinois), and is designed as reopening the oil battle in the Senate. Legislation is designed to "reclaim offshore oil reserves and pledge federal royalties for education," the senators report.

Defense Committee

A committee to study ways of reducing damage to industrial facilities of the oil and gas industries should the United States come under attack from an enemy nation, has been named by Chairman Walter Hallanan, National Petroleum Council. The committee is to study and present recommendations on ways to organize groups to minimize this hazard. Formation of the committee was requested by Interior Department and is headed by Dr. Robert E. Wilson, Standard of Indiana.

★ ★ ★

Refinery Wages High

Refinery workers' wages compared favorably with average weekly earnings for other manufacturing workers in 1953. U. S. Bureau of Labor Statistics reported that refinery workers averaged $93.90 per week in 1950 while other industry workers averaged $71.57.

★ ★ ★

Special Type Metals

New metals are needed before automobiles can be driven by gas turbine engines, due to the terrific heat and stress such engines give out. At present there is not enough of the known metals to go around to support output of 5 to 6,000,000 cars a year, besides all replacement parts and engines. Only a tiny amount of this type metal is available for nonmilitary experimentation in jet and turbine development.

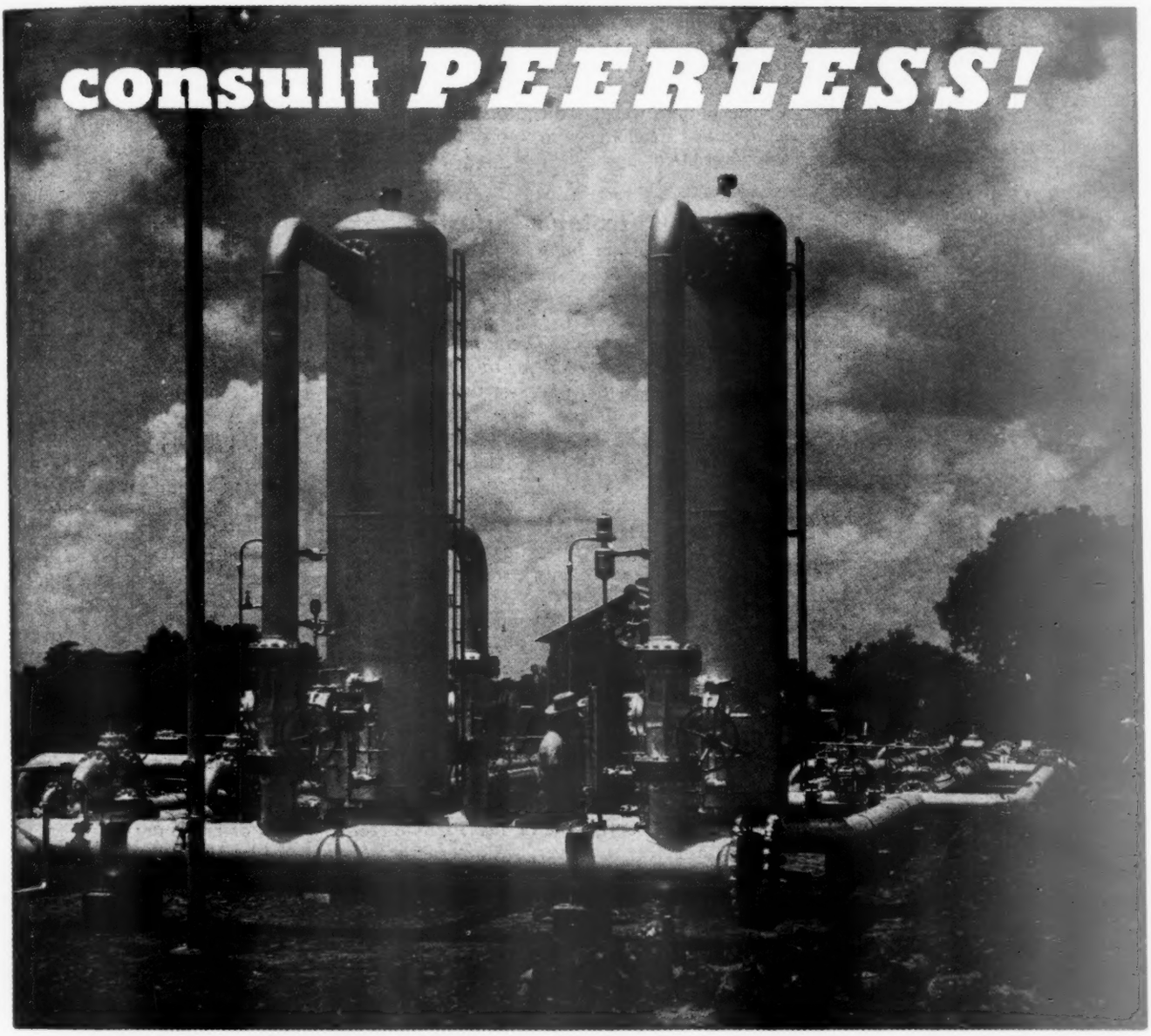
Turbine materials, must retain their strength even at extreme heat. Chief interest now is in molybedenum strongest metal known at great heat that is in supply.

★ ★ ★

Engineering Raises Income

Engineering has doubled the family income in the last 25 years, in terms of real goods, Daniel E. Noble, vice president, Communications and Electronics Division, Motorola, Inc., told members of the Petroleum Electric Supply Association. This income is increased production achieved without extra manhours. Noble declared that with the same amount of manhours spent in 1953 as in 1928, we "stored about $1000 worth of leisure for each man, and still produced twice as much in goods with same work effort."

For GAS SCRUBBERS consult PEERLESS!



The BEST SCRUBBERS for PIPELINES, GATHERING SYSTEMS, COMPRESSOR STATIONS, PLANT INLET SCRUBBERS

Pictured is an installation of TWO 42" x 15' Peerless Gas Scrubbers, at a new Pipeline Compressor Station, in Louisiana. This installation is typical of the many successful applications of Peerless Scrubbers.

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REPRESENTATIVES IN ALL PRINCIPAL CITIES

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Oppose Trade Agreement

Texas Independent Producers and Royalty Owners Association asked Congress to block extension of Reciprocal Trade Agreements Act beyond its June 12 expiration date. Heavy imports of oil are encouraged by the trade agreement, TIPRO claims. In other action TIPRO members, attending a convention in Houston, urged Congress to set import duty or tariff to "equalize competition between high cost domestic production and relatively cheap oil from unreliable foreign sources."

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Oil Imports Exceed Demand

U. S. oil imports are 200,000 to 300,000 bbl per day too high, Minor S. Jameson, Jr., assistant to president, Independent Petroleum Association of America, warned. He said expansion of foreign oil producing capacity from 1946 to 1952 exceeded growth in foreign oil consumption by 1,482,000 bbl per day. Jameson outlined three tests for determining if imports are too high, classified under headings of "domestic availability, ratable taking, and capital expansion."

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Soviet Oil in Sweden

Sweden has signed an agreement to import about 10 per cent of its foreign oil from Russia. Swedish Foreign Ministry reported that a Swedish-Soviet trade agreement for 1954 had been signed, similar to the agreement made in 1940 on commodity exchange and payment. Agreement provides for import of 600,000 tons annually.

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Turkish Oil Bill Passed

New oil bill granting foreign firms right to prospect for and develop oil in Turkey has passed the Grand National Assembly by 266 votes to 17. Original bill had provided for 50-year concessions with extensions of 25 years, but last-minute revision had limited oil concessions to 40 years with possible extension of 20 years.

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Offshore Lease Regulations

Western Oil and Gas Association has offered 10 ways to improve the Interior Department's proposed regulations for continental shelf operations. At the same time the group praised regulations lease forms and tentative drafts of regulations, as showing "understanding of problems involved." Industry men suggested price be determined on a wellhead basis; opposed free storage for royalty oil for up to two months, requesting government take liquid products on current basis. Trend of suggestions was that operators be given greater freedom, with more limited government agency.

★ ★ ★

Warns Petroleum Industry

The petroleum industry has within its present workings the "seeds of its own destruction," Roland V. Rodman, president Western Petroleum Refiners Association, and Anderson-Prichard Oil Corporation president, told members of that group. Excess production to meet national defense needs, are not being used as reserve capacities, but are being used to overflow market demand, Rodman stated. Growing crude oil output, aided by increased imports, outstripped demand during summer of 1953. Rodman called for a proper price relationship between various products from a barrel of crude, dictated by demand and economics.

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Expanded Report

Standard of Indiana's recent report that it was planning a two-year, half billion dollar expansion and modernization program was impressive enough that it needed no inflating. On Page A-12, of the April issue of *The Petroleum Engineer*, however, we reported erroneously that the company had announced a "two-billion dollar expansion and modernization program that will cost about half a billion dollars."

Mexico Rating Up

Mexico is now the seventh among oil-producing nations of the world, according to Eduardo Guzman, chief geologist of Mexico's National Petroleum Company. He said increased exploration during the last four years was responsible. Main petroleum production is now along its Eastern Coast, but indications are favorable for future production in Chihuaba, Coahuila, Baja, California, and Yucatan, Guzman reported.

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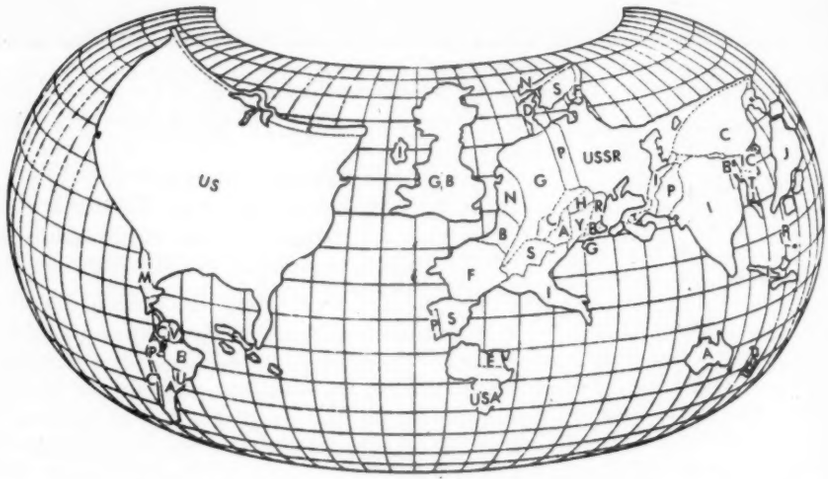
Wages Up

California oil field workers' wages have increased 60 to 70 per cent since 1946, the Oil Producers Agency of California reported. In this same period, according to the report, federal government's cost index has climbed approximately 37 per cent. Average weekly earnings in December 1946, were $56.32 and in December 1953, $95.45, a gain of 69.5 per cent.

★ ★ ★

Oklahoma Reserves High

Oklahoma's proved crude oil reserves increased by 194,608,000 bbl to a total of 1,752,228,000 bbl, American Petroleum Institute has reported. This reserve increase was made despite the fact that the state produced some 199,682,000 bbl of crude during the year. Proved reserves of natural gas and liquids also showed large increases. Liquids including natural gasoline and LPG increased 19,326,000 bbl, and natural gas, 463,544,900,000 cu ft.



Distorted world map showing geographic distribution of world income, taken from a study made by the Twentieth Century Fund, a non-profit research organization. United States and Canada accounted for about half the world's industrial output and northwestern Europe for 20 per cent. Soviet Russia claimed 10 per cent of the world's total, with remaining 20 per cent dispersed. This is based on 1947 data, latest inclusive figures.

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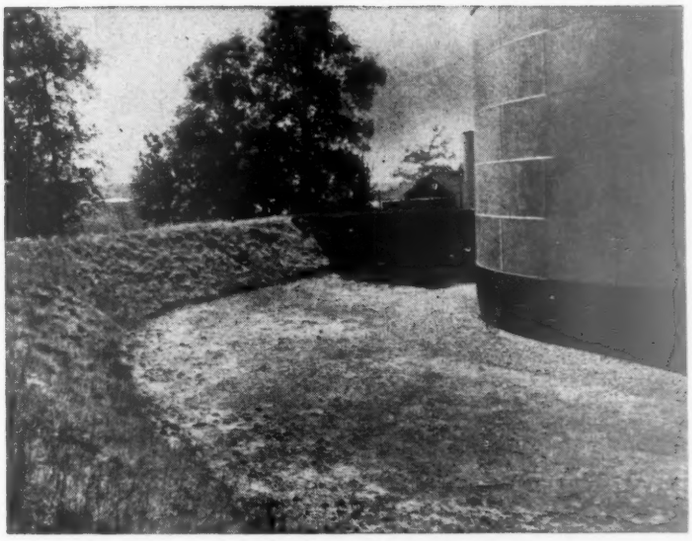

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Petroleum Profile

C. S. MITCHELL
President
Cities Service
Pipe Line Company
Vice President
Cities Service
Oil Company

AS a boy in his home town of Spring Hope, North Carolina, young Charley Mitchell often stopped to watch a chauffeur-driven phaeton carrying an important looking gentleman in a Homburg. It sparked an ambition and drive that has never ceased. Along with his desire to some day have a chauffeur and a phaeton and a Homburg, the lad learned that success depends on doing a lot of hustling.

He has been busy ever since, and today C. S. Mitchell, president of Cities Service Pipe Line, vice president and director of Cities Service Oil Company (Delaware), and office in numerous other organizations, is known at his friends in the industry as a "man in a hurry and a fellow who gets things done."

Hard work at North Carolina State College was rewarded with high honors. Mitchell "made" Phi Kappa Phi, honorary scholastic fraternity, and Tau Beta Pi, honorary engineering fraternity. During summer months, he worked at a variety of jobs, earning his way through school.

In 1930, after graduation, he signed on with Cities Service as a junior engineer and in 1932 transferred to Cities Service Gas as an industrial meter man. To most engineers, tearing down meters and inspecting their innards would seem a fruitless task. Not so for Mitchell. Every job to him is important, regardless of size.

By 1937, he was general inspector, supervising the men who inspect the meters, and in 1938 he was made assistant superintendent of the gas company's Panhandle operations. Another promotion in 1939 made him buyer in the purchasing department of Cities Service Oil Company with headquarters in Bartlesville. The year 1937 was important in another aspect, too. He married Margaret Louise Stein of Miami, Oklahoma.

Known as a man of action, Mitchell was an ideal choice for the task of "expediter" during World War II, when projects often become snarled in a web of Washington's peculiar brand of red tape.

After the war, he was sent to Chicago to expedite the company's expanding marketing division. Competition was great among the oil companies and Cities Service's success in the Chicago area was due largely to "how to make a deal" fundamentals planted by Mitchell.

Two years later Mitchell was recalled to Bartlesville to organize a crude oil purchasing and sales division. On the outside it sounds simple — deliver the right oil in the right amount at the right time at the lowest cost. To do it, however, requires buying, selling, trading, and dickering all over the country — and at the same time.

Cities Service was opening a new division with a "green hand." But the "green hand" had plenty of energy, imagination, and a way with people.

Charley Mitchell became a nomad, living out of a suitcase, here today, two other places tomorrow. Operations continually expanded and in 1953, the activity was renamed crude oil supply division and Mitchell was named manager. During that time, he also had been elected director of Cities Service Oil Company (Delaware) in 1950, president of the pipe line company in 1951, and vice president of the oil company in 1952.

Mitchell was also instrumental in creating a network of pipe lines, to handle both crude and products, that now extends for 13,000 miles. His "deals" have paid off well for the company in the form of joint pipe line ventures with other companies, while building the company's wholly-owned system at the same time.

Mitchell is known as a shrewd but fair operator in the oil industry. Quoting a competitor, "the man is a square shooter, my boys tell me, and I'm sure he is. But he knows all the angles, too. I warn you to keep an eye on him."

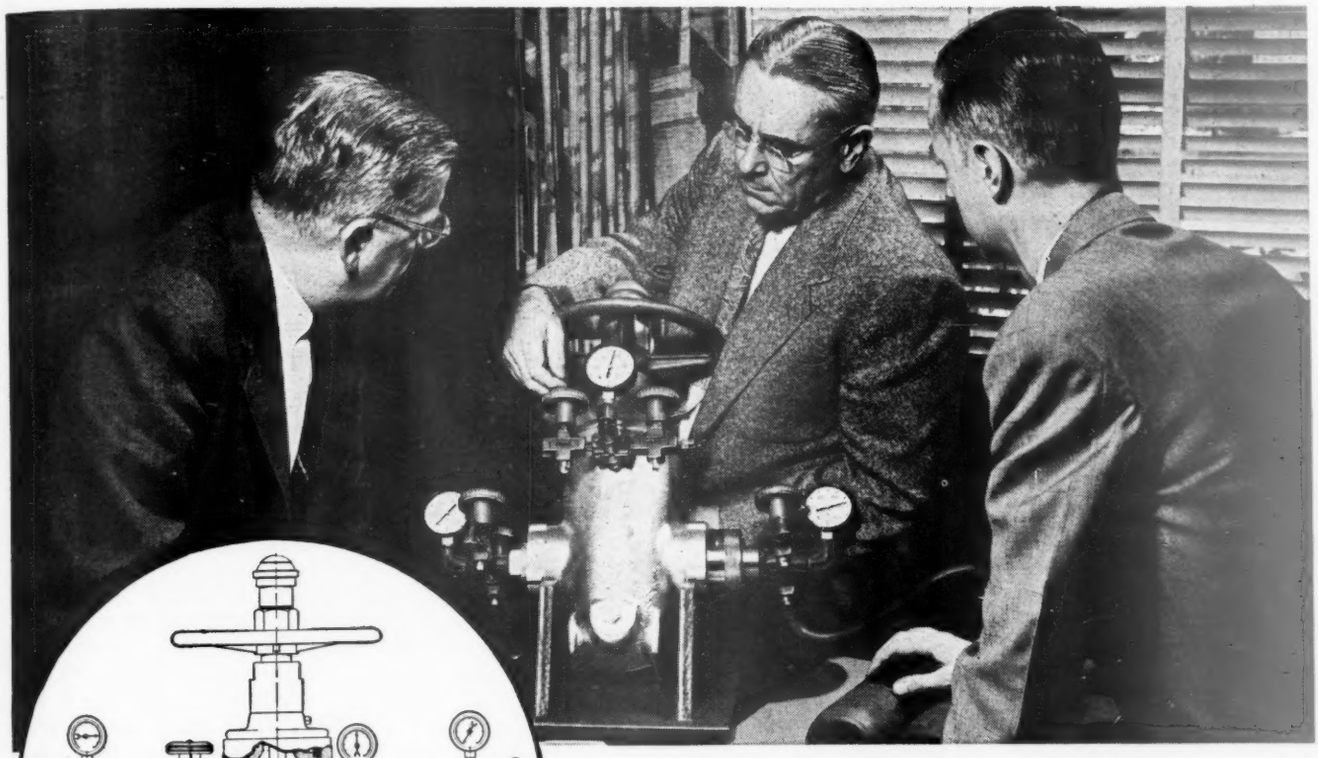
Three things are taken seriously by Mitchell: His family, his company, and his church. Sometimes it's hard to tell which comes first, friends say. The Mitchells have three children, two boys and a girl, and a new home in Bartlesville. He is a member of a laymen's committee and is presently chairman of the church's building committee, one of many jobs he has held in both the parish and diocese of the Episcopalian church.

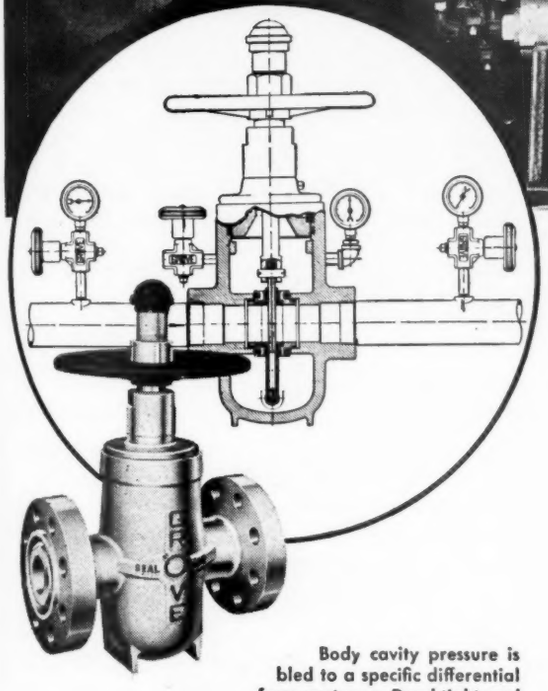
He also has several hobbies. One is golf, described by his wife as "a joke." He plays until one of two things are accomplished — he loses six balls or his score totals half his weight. He has yet to play more than nine holes. Mitchell also fishes. His fishing consists of offering the fish one look at the bait. If this doesn't produce results, the fishing is over. He swears it is fun, though.

A friend recently warned Mitchell about maintaining his rapid pace, "You'll get ulcers." "I'll never get ulcers," he scoffed. After a moment's thought, he reflected ruefully, "I may *give* 'em."

If so, it'll probably be to someone who is pitted against him in a business deal, for ulcers, the doctors have decided, are children of worry. C. S. Mitchell has never had time to spare for worry — nor do those around him.

WE'LL MAKE THIS TEST WHEREVER YOU SUGGEST





Body cavity pressure is bled to a specific differential from upstream. Dead-tight seal is verified by non-variance of cavity pressure gauge.

The only gate valve you can check in the line—any time.

SEE FOR YOURSELF HOW GROVE SEAL-"O"-RING GATE VALVES CAN BE CHECKED IN THE LINE...for positive dead-tight seal and free-moving gate action

Your Grove sales engineer is equipped to demonstrate this new field method of testing and checking the dead-tight seal and free-moving gate action of Grove Seal-"O"-Ring Gate Valves—*right in your office,* or wherever you suggest. Simulating actual conditions, this test proves conclusively that Grove Seal-"O"-Ring Valves hold tight as a line blind, yet permit free movement of the hand-wheel at all times. Also, excess body cavity pressure is automatically relieved *internally* to the upstream line by piston-action of Seal-"O"-Ring seat assemblies, actuated by pressure differential. This test set-up shows how you can install this system for checking Grove valves right in the line—at any-time—without loss of gas or liquid. You must see it—to believe it. Contact your nearest Grove District Office today, to arrange for test demonstration.

GROVE SEAL-"O"-RING Gate Valves

GROVE REGULATOR COMPANY • 65th & Hollis Sts., Oakland 8, California
HOUSTON 4—1901 Calumet St. • **LOS ANGELES 14**—649 So. Olive St. • **NEW YORK 17**—415 Lexington Ave.

GROVE
SIMPLICITY
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4534 No. Baldwin Blvd.	2604 Kermit Hwy.	1334 Fidelity Union Life Bldg.	318 Thompson Bldg.	101 Berkeley St.	3727 Greenway Pl.	331 Sena Drive	2669 Cherry St.

PETROLIC PERSONALITIES

DICK SNEDDON

HOW COME THE THREE-MILE LIMIT

From Alastair Borthwick's column in Scotland's Magazine we read recently that the three-mile limit "began on that day long ago when the nations decided that their borders ought not to stop on the beach where nature had put them, but ought in the interests of security to extend some way out to sea. As the greatest distance a cannon in those days could fire was three miles, the three-mile limit was born and has been upheld by international law ever since."

That is just tossed in as an interesting bit of information but it reminds us that a while ago we ran down to Balboa Bay in California and scampered about Dr. Jay Jakosky's well equipped geophysical fleet, which is presently engaged in some research work at the Institution of Oceanography at La Jolla, after which it will begin offshore seismic work.

We learned from Dr. Jakosky who is president of International Geophysics that one of the vessels was formerly owned by Ed Simonis, erstwhile prexy of Santa Maria Drilling Company, who made so much money in Cuyama that he turned the company lock, stock, and barrell over to his employees.

EQUIPMENT FOLK CONVENE

At the PESA meeting in the Los Angeles Ambassador recently we had the pleasure of hearing Davis Bovaird, prexy of the national organization, make a brief but pointed address that carried excellent advice to the equipment and supply people. In much more expressive terms than we shall use here, he exhorted them to quit talking themselves down and to stop also referring to themselves as "peddlers."

Walk proudly, he advised, in the knowledge that you have made and are still making an essential and substantial contribution to the maintenance and growth of a great industry! These weren't his exact words but that was roughly the sense of them. His wisdom was nicely seasoned with humor and altogether his presentation was both elevating and entertaining.

Coming out of the meeting, we ran into Bill McKissick of the McKissick Products Corporation in Tulsa. Bill was due to take part in a skoot sheet, excuse please, skeet shoot, next day at the Aqua Sierra Sportsmen's Club, whereat we told him we could never enjoy that sort of thing on account of we always feel so sorry for the skeets.

OF THE PIPE MAN AND OTHERS

Russ Metzger, manager of tubular sales for The Colorado Fuel and Iron Corporation, has more pipes than Sherlock Holmes ever had, or Dr. Watson either, and is consequently commonly referred to as "Kaywoodie." Russ is very fond of golf and being of an inventive turn of mind is at this very moment trying to perfect a soundproof sandtrap.

S. L. "Sid" Barber, executive vice president of Taylor Forge and Pipe Works, Chicago, tells us the only reason that he is not one of the best equestrian's in the country is that the stupid animals won't stand still. Sid, incidentally, is also what might be termed a "mathematical" golfer. When he strikes the ball, and he usually keeps on trying until he does, it invariably describes an arc just like people do in geometry classes.

On the other hand, although he doesn't get much time to indulge his hobby, R. L. "Les" Hanes, the Colorado Fuel & Iron executive, is one of the most accomplished fishermen in the northwest. He has sunk the South Platte River so low by yanking out the fish that Denver now stands a full mile above sea level.

BLESSED ARE THE MEEK—ESPECIALLY BOB

And now, with the indulgence of our readers, we would like to skip about the country again picking up bits of gossip here and there like for instance, Bob Meek, district manager for the Ladish Company in New York, finds his spare time occupation in photography, so that although most people require plenty of sunlight for their better health, and maintenance, Bob is developing very nicely in the dark, thank you!

A. W. "Dag" Dagistino, director of purchases for the Lummus Company, sometimes known as Eddie Arcaro, once picked seven winners on the same day at an eastern race track and would have had the eighth if he hadn't run out of mazuma. Once at Santa Anita we plunged terrifically on a filly named Modern Girl but true to her type she didn't get in until 1:30 the next morning.

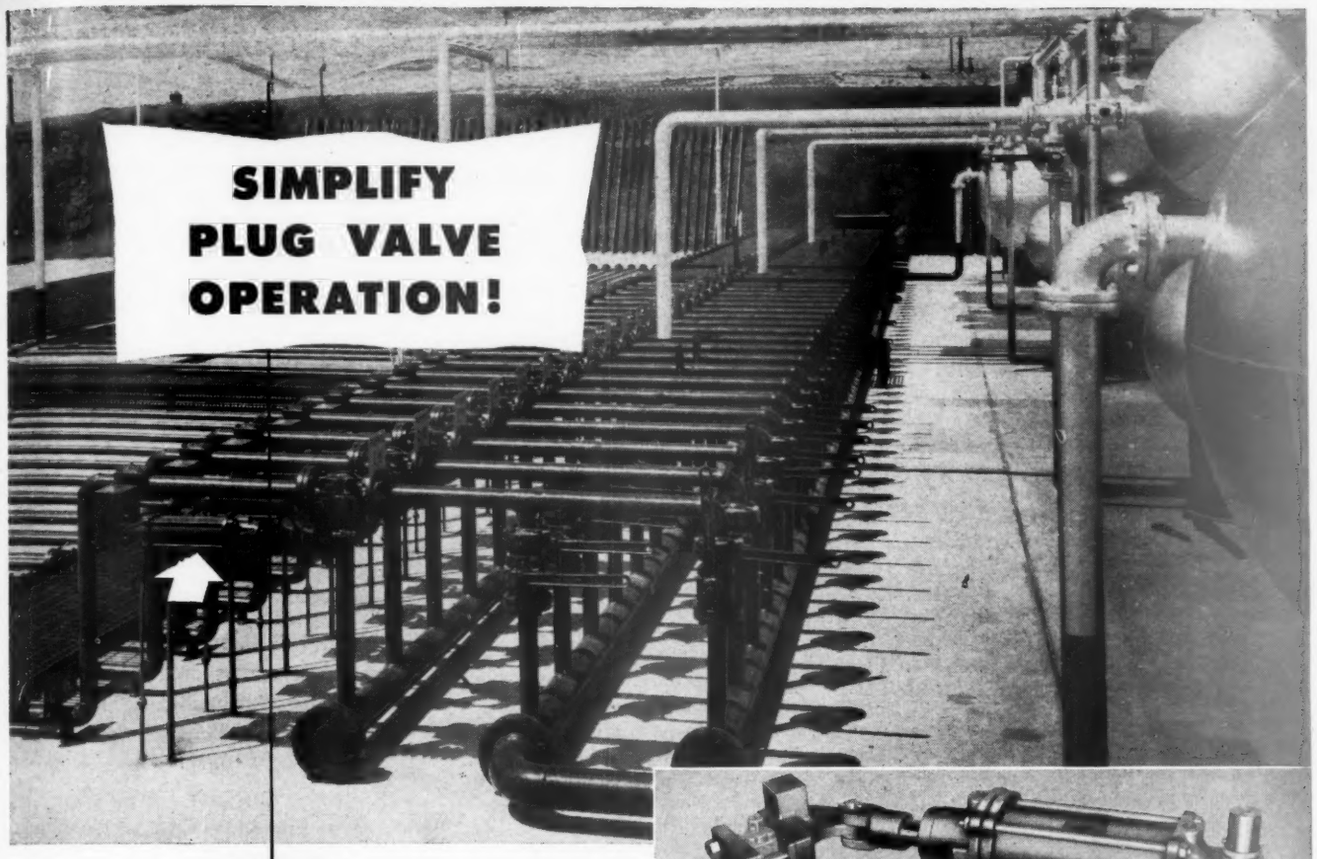
FLOTSAM AND JETSAM

By way of last minute roundup: With our estimable partner, Bill Thornbury, one of the West's most astute tile tossers and oil producers, we entered for the first time in a long and tempestuous domino career, the second round of the La Petroleum Club tournament, at the expense of Dean Walling of Western Geophysical and Ken Fuller of Humble Oil & Refining Company, a pair of real sharpies.

Among world travelers still ambling about in foreign parts are Archie MacDonald, the noted Nineteener, and Bill Geis, the consultant, and past president of the Los Angeles Petroleum Club. Just about to take off for Europe is Willard "Swede" Larson who, with Mrs. Larson, will visit their daughter in Stuttgart, Germany. The daughter is a school teacher with the expeditionary forces.

The Western Pipe Liners Club elected their new officers at a whingding in Santa Maria.

Remember, you can't drive a nail with a sponge no matter how hard you soak it.



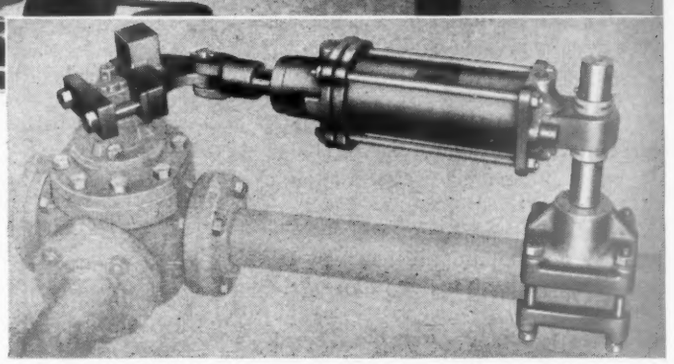
With New Low Cost

Hanna®

Fluid Power

Valve Operators

Hanna's new, low-cost packaged Plug Valve Operator power operates two-position, quarter-turn rotary plug valves. Because these compact units can be installed anywhere and in limited space areas, they eliminate manual control, reduce costly operating time. No more ladder climbing, long distance walking, wall scaling or disturbing flooring to turn valves on and off. With the new Hanna Fluid Power Plug Valve Operator, control is quick, convenient effortless. Installation is likewise simple. No special tools are required. A Hanna Engineer will be glad to show you how this new departure in valve operation can be adapted to your needs with profit.



The adaptability of the new Hanna Plug Valve Operator is shown in this application of a battery of Hanna units installed on Shell Oil Company's Brea Tank Farm in California.

The inset photo shows in bold outline the Hanna Valve Operator in a typical application.

- **Eliminates manual operation**
- **Provides dependable, positive control**
- **Saves costly operating time**

HANNA FEATURES • HANNA ENGINEERED

Ready to install—no special tools needed.
Operates valves ranging in size from 1" to 12".
Operates with air, oil, water or petroleum gases.
Line pressures from 50 to 150 P.S.I.
Manual, semi-automatic, automatic or remote control.
Simple and rugged—trouble-free operation.

SEND FOR FREE FOLDER
TODAY

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT • CYLINDERS • VALVES • RIVETERS

1774 Elston Avenue, Chicago 22, Illinois

LETTERS

Wants to Reprint

To The Petroleum Engineer:

We request permission to print your article that appeared in the February issue of *The Petroleum Engineer*, "Oklahoma to Revise Proration System" on Page A-4 under "Course of Oil" in our February issue of *Transportation News*.

R. D. Kraus

Standard Oil Company of Ohio

Seeks Turkish Oil Job

To The Petroleum Engineer:

Every day you read from your local newspapers or hear that in Turkey petroleum plants will produce by the help of American petroleum producers.

Really, the Eastern part of Turkey has very rich petroleum plants where I visited two months ago. I wonder is there any company who has applied to our government to work in our country.

If you know any company that is coming to Turkey, will you please let me know the name of the company. I would like to apply as an interpreter-translator, partsman, storekeeper, property accountant, time keeper, ex-expeditor. I can be the keyman of the company.

I am a Moslem, 28 years old. I speak fluently Turkish and English. I am fully conversant with all kinds of automotive and spare parts, as I have been dealing with such sales over ten years.

Nusret F. Un.

Istanbul, Turkey

Article Brings Inquiries

To The Petroleum Engineer:

I want to take this opportunity of expressing to you my personal appreciation at being permitted to address the readers of your publication through the courtesy you extended me in the January 1954 issue of *The Petroleum Engineer*.

Readers of the article "New Technique in Oil Production" which began on page B-39 of that issue, have not only written relative to the contents of the paper but have almost run us out of stock of reprints of the article.

It is most gratifying that along with letters from production engineers and oil operators we have received numerous requests for reprints from numerous schools of petroleum engineering. Many of your readers have not taken the time to write but have come to this installation to observe it in actual operation.

Our primary purpose in installing this new production method of vertical drive in an actual oil field was to conduct it as a laboratory which would be open to inspection at all times to anyone associated with the production end of the oil industry. The fact we have received inquiries and visitors from all parts of the oil producing areas of this country in this very short time following distribution of your January issue is eloquent testimony to the character of news and technical service your publications bring to the far reaches of the industry. Again I thank you for the courtesy you extended to us and, through you, I wish to express the pleasure we have received from the letters of inquiry which have come to our desk and the many additional friends we have met in those who have visited this property.

Ralph Spearow

The Spearow Company, Inc.

Liked Supervisory Article

To The Petroleum Engineer:

Looking through the March issue of your very fine publication, among other things which interested me was an article by A. O. Ohmann entitled "Supervisory and Management Development," which was carried on Page E-25.

I particularly liked Ohmann's approach to supervision, a recognition of the "more important intangibles of attitudes, values and philosophies" on the part of the supervisor. This follows very closely my recent and continuing training under a very fine instructor who constantly stresses self-development and the importance and necessity of replacing our own short-range selfish interests for more worthy long-range aims and philosophies.

If possible, I should like to have about three or four copies of Ohmann's speech. Several, here, to whom I showed this article, have expressed a desire to have a copy.

Katherine M. Livada

Tretolite Company of California
Los Angeles, California

234 NEW OIL AND GAS FIELDS . .

. . were discovered in Kansas last year, where operators hung up all-time discovery and drilling records. Seventy-nine counties produced the crude, gas, and refined products to give Kansas the highest petroleum income in history — $385,000,000.

Here is a lineup of some of the articles you'll get in your Kansas June issue:

. . Geology of Kansas
. . Engineering and Production Problems
. . Secondary Recovery Projects
. . Properties of Crudes
. . Petroleum Economics
. . Logging Techniques and Analysis
. . Fracturing Methods
. . Newest Refinery Unit

Read the full story of Kansas and its place in the oil industry, plus many more engineering-operating articles in your June issue.

MAJOR PIPE LINE OPERATED BY LOW-COST PURCHASED

Electric Power

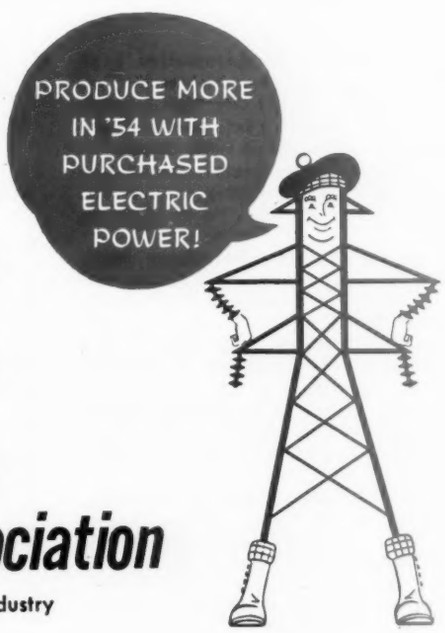
Pictured here is one of four modern stations on a major electric-powered pipe line boasting a total of 22,000 horsepower, and a 24-hour capacity of 340,000 barrels.

Clean as a kitchen, this modern, compact station houses five electric pumps totaling 5,550 horsepower — and the entire plant may be operated by remote control, if desired!

Purchased Electric Power does the job easier — with less attention; maintenance costs are lower; all-over operating expenses are kept to a minimum.

Let Purchased Electric Power go to work for you, too! There's a Power Engineer at your nearest Electric Power Company who will be glad to show you how LOW COST POWER fits into *your* picture!

CALL YOUR NEAREST ELECTRIC SERVICE COMPANY for more facts, or address your request to P. O. Box 2771, Dallas, Texas



Petroleum Electric Power association

ORGANIZED in the interest of greater service to the petroleum industry

To obtain more information on products advertised see page E-57

MEETINGS ★

May 6-7—**American Petroleum Institute,** Division of Production, Pacific Coast district, Statler Hotel, Los Angeles, California.

May 9-12—**Liquefied Petroleum Gas Association,** annual, Conrad Hilton Hotel, Chicago, Illinois.

May 10-12—**American Petroleum Institute,** Division of Transportation, Products Pipe Line Conference, Warwick Hotel, Philadelphia, Pennsylvania.

May 10-12—**International Fire Fighters Association,** annual, San Angelo, Texas.

May 10-12—**Purdue Industrial Waste Conference,** annual, Purdue Memorial Union, Lafayette, Indiana.

May 10-13—**American Petroleum Institute,** Division of Refining, midyear meeting, Rice Hotel, Houston, Texas.

May 12-13—**Pacific Coast Gas Association,** gas supply and transmission conference, Mark Hopkins Hotel, San Francisco, California.

May 13-14—**American Association of Oil Well Drilling Contractors,** safety clinic, Baker Hotel, Dallas, Texas.

May 13-14—**Society Exploration Geophysicists,** Gulf Coast regional, Houston, Texas.

May 14-15—**Interstate Oil Compact Commission,** General Oglethorpe Hotel, Savannah, Georgia.

May 16-19—**American Institute of Chemical Engineers,** Hotel Kimball, Springfield, Massachusetts.

May 20-21—**Kentucky Oil and Gas Association,** annual, Lafayette Hotel, Lexington, Kentucky.

May 24-26—**American Gas Association** Production and Chemical Conference, William Penn, Pittsburgh, Pennsylvania.

May 27-28—**Natural Gas and Petroleum Association of Canada,** Prince Edward Hotel, Windsor, Ontario, Canada.

May 31-June 5—**American Petroleum Institute,** Division of Production, midyear committee conference, St. Francis Hotel, San Francisco, California.

June 2-4—**Texas College of Arts and Industries,** Short Course in Gas Technology, Texas A & I, Kingsville, Texas.

June 3-4—**Pennsylvania Grade Crude Oil Association,** annual, Hotel William Penn, Pittsburgh, Pennsylvania.

June 6-11—**Society of Automotive Engineers,** summer meeting, Ambassador and Carlton Hotels, Atlantic City, New Jersey.

June 9-11—**Oil Industry Information Committee,** Edgewater Beach Hotel, Chicago.

June 13-18—**American Society for Testing Materials,** annual meeting and exhibits, Sherman and Morrison Hotels, Chicago, Illinois.

June 17-19—**American Petroleum Institute,** Division of Production, Eastern district, Greenbrier Hotel, White Sulphur Springs, West Virginia.

June 17-19—**National Oil Scouts and Landmen's Association,** annual, New Orleans, Louisiana.

June 20-25—**American Institute of Chemical Engineers and Institute of Nuclear Energy,** University of Michigan, Ann Arbor, Michigan.

June 20-24—**Canadian Gas Association,** Banff Springs Hotel, Banff, Alberta, Canada.

June 20-July 4—**California Institute of Technology,** annual conferences on Personnel Administration and Managerial Development, Industrial Relations Section, Pasadena, California.

June 21-25—**American Institute of Electrical Engineers,** combined summer and Pacific general meeting, Biltmore Hotel, Los Angeles, California.

June 24-25—**Western Petroleum Refiners Association,** regional, Leonard refineries auditorium, Alma, Michigan.

June 25-26—**Southern Gas Association,** transmission management conference, Hotel Adolphus, Dallas, Texas.

June 27-July 1—**Petroleum Equipment Suppliers Association,** Manior Richelieu, Murray Bay, Quebec, Canada.

July 21-24—**Human Relations in Industry Conference** (YMCA), Silver Bay, New Jersey.

July 23—**Southern Gas Association,** communications conference, Rice Hotel, Houston, Texas.

July 24—**Southern Gas Association,** dispatcher conference, Rice Hotel, Houston, Texas.

Aug. 17-19—**Society of Automotive Engineers,** International West Coast meeting, Georgia Hotel, Vancouver, B. C., Canada.

Aug. 20-21—**Southern Gas Association,** natural gas processing and pipe line operations conference, Herring Hotel, Amarillo, Texas.

August 26-28 (tentative)—**Intermountain Association of Petroleum Geologists,** annual field conference, Price, Utah.

Sept. 6-11—**American Chemical Society,** national meeting, Conrad Hilton Hotel, Chicago, Illinois.

Sept. 7-8—**Association of Desk and Derrick Clubs of North America,** annual convention, Banff Springs Hotel, Banff, Alberta, Canada.

Sept. 8-10—**Oil Industry Information Committee,** Chicago, Illinois.

Sept. 8-10—**Pacific Coast Gas Association,** annual, Vancouver Hotel, Vancouver, B. C.

Sept. 9-11—**Interstate Oil Compact Commission,** Omaha, Nebraska.

Sept. 12-16—**American Institute of Chemical Engineers,** Colorado Hotel, Glenwood Springs, Colorado.

Sept. 13-24—**Instrument Society of America,** International Instrument Congress and Exposition and National Instrument Conference and Exhibit, Philadelphia, Pennsylvania.

Sept. 15-17—**National Petroleum Association,** annual, Traymore Hotel, Atlantic City, New Jersey.

NOMADS TO MEET

New York N. Y., Chapter, First Monday of the Month, Biltmore Hotel, New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First or Second Monday of the Month. Secretary, Glen Tableman.

Sept. 16-17—**Mid-Continent Oil and Gas Association,** Louisiana-Arkansas Division, annual, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 27-30—**American Society of Mechanical Engineers,** Petroleum Division, annual, Statler Hotel, Los Angeles, California.

Sept. 27-29—**American Institute of Electrical Engineers,** electrical conference for petroleum industry, Mayo Hotel, Tulsa, Oklahoma.

October 4-6—**Petroleum Electric Power Association,** annual, Jung Hotel, New Orleans, Louisiana.

Oct. 4-6—**Texas Mid-Continent Oil and Gas Association,** annual, San Antonio, Texas.

Oct. 7-8—**California Natural Gasoline Association,** annual, Ambassador Hotel, Los Angeles, California.

Oct. 11-13—**American Association of Oil Well Drilling Contractors,** annual, Biltmore Hotel, Los Angeles, California.

Oct. 11-14—**American Gas Association,** Atlantic City, New Jersey, hotel to be named.

Oct. 14-17—**Permian Basin Oil Show,** Odessa, Texas.

Oct. 16—**Southern Gas Association,** transmission management conference, Rice Hotel, Houston, Texas.

Oct. 25-26—**Independent Petroleum Association of America,** annual, Mayo Hotel, Tulsa, Oklahoma.

Oct. 25-29—**American Institute of Electrical Engineers** (tentative date), Fall general meeting, Chicago, Illinois.

Oct. 26-27—**Society of Automotive Engineers,** national diesel engine meeting, Statler Hotel, Cleveland, Ohio.

Nov. 1-5—**American Society for Metals,** national, Palmer House, Chicago, Illinois.

Nov. 8-11—**American Petroleum Institute,** annual, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 28-Dec. 3—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Dec. 8-10—**Oil Industry Information Committee,** Waldorf-Astoria Hotel, New York.

Dec. 12-15—**American Institute of Chemical Engineers,** annual, Statler Hotel, New York, New York.

1955

March 9-11—**American Petroleum Institute,** Southwestern District, Division of Production, Jung Hotel, New Orleans, Louisiana.

March 20-23—**American Institute of Chemical Engineers,** Kentucky Hotel, Louisville, Kentucky.

April 19-21—**Southwestern Gas Measurement Short Course,** University of Oklahoma, Norman, Oklahoma.

May 1-4—**American Institute of Chemical Engineers,** Shamrock Hotel, Houston, Texas.

May 14-22, 1955—**Deutsche Gesellschaft fur Chemisches Apparatewesen,** chemical plant and apparatus exhibition and congress, Frankfurt am Main, Germany.

June 1-9, 1955—**Fourth World Petroleum Congress,** Rome, Italy.

Sept. 12-16—**Instrument Society of America,** National Instrument conference and exhibit, Los Angeles, California.

Sept. 25-28—**American Institute of Chemical Engineers,** Lake Placid Club, New York, New York.

Nov. 14-17—**American Petroleum Institute,** annual, San Francisco, California.

Nov. 27-30—**American Institute of Chemical Engineers,** annual, Statler Hotel, Detroit, Michigan.

Gas well on Clear Creek structure, Emery County, Utah. *Mid-Continent Petroleum Annual Report*

OIL COMPANY ANNUAL REPORTS FOR 1953

Industry to Spend Record $4.5 Billion in '54

Competition pushes petroleum industry to highest level in its history

*ERNESTINE ADAMS**

LIKE a sleeper who has set an alarm clock in his mind, the petroleum industry in 1953 restlessly listened for the recession that never quite went off. It complained and progressed through the greatest year in its history.

This is the story found in the 1953 annual reports of oil companies.

There were many things to complain about but the favorable factors outweighed the problems. Instead of crossing a bridge of trouble before coming to it, the oil industry managed to cross a bridge of economic triumph without noticing it.

It was the first time in almost 15 years that the industry felt acutely the burden of over-supply. Nearly every annual report stresses this problem as the outstanding one of 1953. Those who do not import oil feel that foreign oil has overbalanced demand; importers point out the idle 1,000,000 productive capacity built for U. S. defense but difficult to hold for that purpose.

EXCLUSIVE

Typical of many statements is that of Toklan Royalty Company, which reads:

"The absorption of domestic markets by steadily mounting imports of foreign oil has had an adverse effect upon all domestic oil producers during the past year and undoubtedly will have an even greater effect during the year ahead. If continued at present rates, it will force 'cut backs' in domestic production which will seriously discourage new development. Ultimately, and in the not too distant future, this will

*Managing Editor, The Petroleum Engineer.

TABLE 1. FINANCIAL STATISTICS FOR 1953 TAKEN FROM OIL COMPANY ANNUAL REPORTS

Company	No. years in business	Gross income before taxes, 1953 ($1000)	Gross income per cent of 1952	Net income after taxes, 1953 ($1000)	Net income per cent of 1952	Direct taxes, 1953 ($1000)	Direct taxes, 1952 ($1000)	Taxes collected for govts. ($1000)	Common stock, 1000 shares	Price per share, Dec. 1953	Net income per share	Direct taxes per share	Div. per share	Number employees	Payroll and benefits ($1000)	Net fixed assets 12-31-52 ($1000)	Working capital ($1000)	Depreciation depletion intangibles ($1000)	Cap. exp. 1952 ($1000)	Cap. exp. 1953 ($1000)	Cap. exp. 1954, est. ($1000)
*Amerada Pet. Corp.	33	85,697	114	18,446	116	.....	.....	.....	3,155	$165	5.85	.....	3.00	.....	.....	60,854	29,807	10,794	.....	42,675	43,000
*American Republics	38	25,694	116	5,515	105	1,390	1,300	.....	1,500	47½	3.68	.93	1.75	550	.....	27,477	6,829	2,833	10,211	6,720	.....
*Anderson-Prichard	.....	53,271	150	4,442	118	2,413	1,447	.....	813	43⅛	5.46	2.97	2.00	.....	.....	36,820	8,141	.....	7,349	13,248	.....
Argo Oil	.....	9,113	130	4,212	120	254	528	.....	2,000	18	2.11	.13	0.99	.....	.....	16,854	1,499	1,134	4,484	4,360	4,360
*Ashland Oil & Refining[7]	30	238,362	104	8,408[2]	148	7,725	7,679	25,000	5,399	11⅝	1.26	1.43	1.00	4,400	.....	76,308	45,071	13,072	32,238	23,791	14,000
*Atlantic Refining	83	611,583	97	49,755	123	25,152	31,700	61,858	8,962	28	5.41	2.81	2.00	21,188	99,454	390,764	36,786	37,971	72,880	82,129	82,000
*Bishop Oil	.....	1,822	107	292	219	43,340	61,000	.....	372	11	.78	.12	0.20	86	.....	2,678	539	357	357	578	.....
*British-American	47	190,548	107	19,735	140	24,060	22,518	37,500	8,208	21¾	2.40	2.93	0.65	5,101	24,000	136,578	35,953	12,553	37,950	33,603	34,000
*Cities Service	44	693,467	102	50,720	103	51,900	59,987	149,000	3,887	78	13.05	13.35	5.00	.....	.....	701,676	266,258	59,617	89,042	131,275	.....
*Continental Oil	.....	476,842	120	40,875	107	25,574	24,223	50,714	9,737	52	4.20	2.63	2.60	9,183	46,800	246,656	68,199	47,965	90,748	84,968	87,000
Cosden Petroleum	16	38,628	114	2,342	113	1,147	2,571	629	675	15⅞	3.47	1.70	1.00	544	2,639	11,383	3,688	938	2,089	4,700	5,500
*Deep Rock	55	41,844	107	1,531	169	609	508	4,614	469	35⅛	3.26	.053	2.00	995	5,621	24,545	10,195	3,025	5,923	4,502	3,700
*Delhi Oil	8	4,106	.....	-(690)	.....	224	1,454	.....	2,579	21¾	.....	.....	Stk.	135	.....	18,510	-(12,911)	2,901	.....	2,585	.....
Derby Oil	.....	21,365	121	1,233	126	713	322	.....	464	16⅛	2.66	1.54	1.00	386	2,003	11,222	2,935	1,104	2,630	1,879	.....
*Douglas of California	24	21,156	118	639	104	382	408	.....	1,151	7	0.55	.....	0.10	379	2,143	3,168	1,052	664	793	1,487	2,000
*Drilling & Exploration	25	7,426	99	731	81	.....	.....	.....	1,482	8½	0.49	None	None	384	2,265	9,031	3,550	1,563	2,091	3,581	3,000
*General American	17	13,667	108	5,387	116	843	425	.....	1,138	40½	4.71	.08	0.60[1]	332	1,706	26,343	4,737	3,278	.....	7,373	.....
General Crude Oil	.....	11,439	112	2,864	125	.....	1,111	.....	1,793	41	1.60	.....	.10	.....	.....	.....	.....	.....	4,142	.....	.....
*Gulf Oil	53	1,640,872	107	175,036	123	135,361	137,611	233,183	24,542	46¼	7.13	5.51	2.00[1]	48,000	219,879	890,538	424,644	138,831	192,688	221,598	250,000
*Hancock Oil[8]	31	49,618	79	11,950	121[4]	2,686	2,586	7,527	3,113	20	3.84	0.86	0.55[1]	325	.....	2,198	28,820	2,317	1,614	595	.....
Honolulu	44	29,650	118	10,172	139	3,542	3,749	.....	1,875	57	5.42	1.89	2.50	489	3,499	41,491	14,731	4,004	6,700	9,300	15,000
Houston Oil	53	32,659	119	6,710	106	3,655	3,222	.....	1,328	66¾	5.05	2.75	2.25	729	3,782	66,836	6,108	5,308	12,189	11,299	11,514
Humble Oil & Refining[9]	43	1,024,557	105	164,258	113	81,957	66,000	.....	35,837	56½	4.58	2.29	2.28	18,821	127,767	915,822	126,566	83,000	160,280	154,224	.....
*Husky Oil[3]	15	9,057	130	587	81	.....	.....	.....	2,338	6	.17	.....	Stk.	.....	.....	8,998	3,143	1,070	1,651	2,550	.....
*Kerr-McGee[3]	.....	32,339	121	2,669	119	683	686	.....	1,260	41	2.12	.54	0.60	.....	5,978	21,960	9,494	2,542	4,712	8,162	.....
*Kirby Oil	33	3,868	109	1,014	88	.....	.....	.....	503	34¼	1.71	.....	Stk.	.....	.....	6,342	2,189	609	.....	.....	.....
Lion Oil	31	89,959	102	10,688	105	8,031	8,050	9,620	3,091	29⅞	3.46	2.60	2.00	2,732	14,990	99,039	25,784	7,230	16,021	33,580	21,455
Louisiana Land & Expl.	.....	22,162	121	10,602	125	8,708	7,726	.....	2,977	51⅜	3.56	2.92	3.00	67	.....	15,467	5,477	423	.....	2,425	1,900
*Maracaibo	.....	1,968	162	429	89	385	.....	.....	495	7	0.87	0.78	0.30	.....	.....	5,589	-(272)	603	.....	.....	.....
Mid-Continent Petroleum	41	174,455	105	14,394	92	23,242	22,669	16,567	1,858	66	7.75	1.25	4.00	.....	.....	90,523	63,449	1,366	19,747	17,075	.....
*Middle States Petroleum	24	11,407	111	2,550	118	851	800	.....	2,317	12⅜	1.10	0.37	Stk.	.....	.....	31,113	4,522	3,104	5,930	6,400	.....
Mid-West Refineries	20	13,725	113	301	90	461	.....	1,016	589	2	0.46	0.78	Stk.	.....	.....	3,390	1,184	361	.....	432	250
Monterey	3	8,142	.....	2,001	.....	617	.....	.....	1,272	33⅝	1.57	0.49	0.20	230	.....	26,577	2,313	2,430	.....	2,000	2,400
*Ohio Oil	66	243,655	108	43,539	111	24,108	22,221	20,000	6,563	53¾	6.63	3.67	3.25	6,262	33,634	192,257	64,117	16,913	46,224	47,399	.....
*Pacific Western	25	23,289	123	11,673[5]	130	.....	.....	.....	4,988	31⅛	2.24	.....	Stk.	.....	.....	29,564	15,998	2,331	.....	.....	.....
Pan American Pet. & Trans.[10]	.....	435,939	102	20,983	100	21,603	27,398	69,642	4,703	45½	4.45	4.59	1.75	8,584	46,422	174,358	38,879	13,675	31,016	38,770	.....
*Panhandle Oil	38	13,105	107	1,065	121	641	563	.....	1,593	6	0.67	0.40	0.30	300	.....	10,993	2,333	1,345	1,000	650	1,000
*Phillips Petroleum	36	765,221	106	76,760	102	39,384	32,383	133,000	14,614	53½	5.25	2.70	2.60	22,693	133,043	775,461	151,468	84,593	190,402	169,617	.....
*Plymouth Oil	30	96,549	92	8,059	84	5,159	5,632	.....	2,429	23⅝	3.32	2.12	1.60[1]	1,212	.....	47,269	19,537	6,399	10,034	11,522	.....
Pure Oil	40	368,027	108	27,105	99	20,762	20,130	.....	4,068	46⅜	6.12	5.10	2.50	.....	.....	251,236	83,592	22,258	39,000	43,000	42,000
Quaker State	24	48,585	100	2,096	113	2,521	2,136	5,164	825	21⅜	2.27	3.06	2.00	.....	.....	13,480	9,301	2,208	5,495	2,272	.....
*Richfield Oil	42	202,039	112	28,525	111	24,133	26,507	40,927	4,000	48	7.13	6.03	3.50	5,200	28,650	165,645	62,033	15,172	26,519	62,951	.....
*Seaboard Oil	35	38,203	109	6,540	97	.....	.....	.....	1,244	87½	5.36	.....	2.50	.....	.....	34,104	10,526	11,580	.....	.....	.....
Shamrock Oil & Gas	25	34,106	107	5,682	116	3,184	2,762	4,890	1,484	40¼	3.83	2.15	2.00[1]	767	4,405	37,652	4,120	17,125	6,129	8,687	8,112
*Shell Oil	41	1,269,551	111	115,407	127	102,112	89,730	203,490	13,740	77	8.40	7.43	3.00	34,660	233,000	565,369	191,695	153,837	206,141	237,712	238,000
*Signal Oil & Gas	31	49,256	114	9,266	127	4,804	3,908	.....	3,559	19¾	2.60	1.35	0.55	682	4,309	46,173	13,309	4,386	.....	.....	.....
*Sinclair Oil	38	935,465	109	68,061	88[10]	42,872	36,279	162,000	12,306	31¾	5.53	3.48	2.60	23,377	126,030	720,101	238,748	54,468	181,134	146,879	130,000
Skelly Oil	34	215,317	104	31,277	112	10,574	10,212	21,610	5,746	35½	5.44	1.84	1.62	4,725	22,796	201,829	42,496	23,607	37,543	41,752	41,000
*Socony-Vacuum	88	1,674,276	103	187,250	109	104,986	95,521	.....	35,512	35½	5.35	2.95	2.25	67,000	240,000[6]	1,069,331	477,735	133,225	239,177	225,240	.....
South Penn Oil	64	58,294	103	6,218	86	4,851	5,643	4,686	1,697	29	3.66	2.86	2.50	2,597	11,701	25,584	21,974	5,443	8,113	5,950	.....
*Standard of California	75	1,156,757	106	189,453	109	106,324	80,870	144,789	28,673	52⅞	6.61	3.71	3.00	34,940	183,859	1,037,659	273,240	108,115	225,565	223,602	275,000
Standard of Indiana	65	1,729,000	107	124,830	104	94,729	92,677	254,523	15,387	68½	8.11	6.16	3.86[1]	50,870	313,594	1,325,447	407,470	113,397	204,300	209,157	250,000[8]
*Standard of New Jersey	71	4,269,630	103	552,826	106	410,800	371,600	419,000	60,571	72	9.13	6.78	4.50	119,000	691,900	2,069,781	1,339,077	269,082	498,051	508,700	510,000
*Standard of Ohio	84	336,026	110	21,218	120	18,057	19,259	53,021	4,011	32	5.08	4.50	2.40	11,136	59,923	169,771	71,553	19,109	26,173	37,010	40,000
*Sun Oil	53	672,200	109	45,154	105	36,278	32,350	106,841	7,730	69¾	5.85	4.69	1.00[1]	24,856	131,685	320,066	78,080	72,177	111,600	129,300	.....
*Sunray Oil	33	133,169	104	27,573	112	15,685	13,572	.....	10,280	16⅛	2.54	1.52	1.20	2,184	.....	230,471	44,997	29,560	32,803	33,495	.....
*Superior Oil[11]	33	73,143	107	12,000	101	5,224	4,870	.....	423	650	28.37	12.35	1.00	2,824	.....	93,450	22,381	25,152	39,551	.....	.....
*Texas Company	52	1,631,651	103	192,600	106	101,210	93,902	283,925	27,476	57⅝	7.01	3.68	3.40	41,320	226,550	1,018,238	484,711	151,375	224,766	229,957	275,000
*Texas Gulf Prod.	23	11,600	112	4,231	133	1,098	1,262	.....	1,218	39	3.47	0.90	1.55	190	1,214	20,949	3,536	3,258	3,644	5,447	7,000
*Texas Pacific Coal & Oil	65	21,498	112	7,599	111	2,751	2,603	.....	1,722	34¾	4.29	1.55	1.65	408	.....	35,323	7,451	3,997	6,574	7,878	.....

[See notes on next page.

XUM

Company	No. years in business	Gross income before taxes, 1953 ($1000)	Gross income per cent of 1952	Net income after taxes, 1952 ($1000)	Net income per cent of 1952	Direct taxes, 1953 ($1000)	Direct taxes, 1952 ($1000)	Taxes collected for govts. ($1000)	Common stock, 1000 shares	Price per share, Dec. 1953	Net income per share	Direct taxes per share	Div. per share	Number employees	Payroll and benefits ($1000)	Net fixed assets 12-31-52 ($1000)	Working capital ($1000)	Depreciation depletion intangibles ($1000)	Cap. exp. 1952 ($1000)	Cap. exp. 1953 ($1000)	Cap. exp. 1954, est. ($1000)
•Tide Water Associated	75	473,437	111	36,952	119	19,980	21,420	60,178	12,794	20½	2.89	1.56	1.15	10,494	58,914	207,137	88,011	27,743	40,514	48,281	
Tokian Royalty	14	1,102	91	243	96	15	38	85	865	4½	0.28	0.10	0.15	43	176	2,135	1,109	425		692	400
•Union of California	64	325,104	113	38,100	138	21,822	12,931	55,239	5,809	38½	6.41	3.76	2.00[1]	9,263	55,564	322,684	93,155	47,581	71,383	71,587	92,607
•Union Sulphur & Oil	59	21,264	101	2,530	92	1,350	1,540		895	37¾	2.83	1.50	1.40			21,349	13,468	3,162		9,096	
Universal Consolidated	31	5,286	116	2,210	170	959	887		583	58	3.79	1.64	2.50	111	645	17,904	6,170	1,005		436	
Utah Southern Oil Co.		2,432	115	887	121	355			600	15	1.48	0.59	0.50			1,187	501	108		463	
Warren Petroleum[2]		115,448	111	10,230	125	6,564	6,607		1,700	30½	6.02	3.86	1.60	1,949	9,310	82,698	9,231	8,354	18,934	14,463	
White Eagle Oil	35	9,508	101	1,022	91	50	100		1,232	12½	0.91	0.45	0.20[1]	495		11,808	2,066	2,725		3,000	3,500
Wilcox Oil	36	8,541	83	928	120	349	215		281	21¼	3.30	1.24	1.00	226	996	5,628	1,640	768	1,780	920	
Woodley Petroleum	31	2,858	104	408	103	196			662	33	0.50	0.30	0.50	79	433	8,045	4,353	526		2,632	3,300

• Has foreign operations. [1] Also stock. [2] Net income for 1952 reduced retroactively from $14,249,117 to $5,700,273 to account for loss on Spraberry properties. [3] Fiscal year ends June 30. [4] Adjusted for the $7,746,904 tidelands payment accumulated since 1947. [5] Includes income of subsidiaries in other industries. Operating net $5,719,036—273% of 1952. [6] For 43,500 U. S. employees only. [7] Fiscal year ends September 30. [8] Estimated from announced 2-year half-billion expansion plans. [9] 72% owned by Jersey Standard. [10] Majority stock owned by Standard of Indiana. [11] Before special credit of $9,630,000 in 1952. [12] Fiscal year ends August 31.

Imports Are Question of the Year...

bring about a reliance upon oil imports which will gravely impair the threat to national security. The final decision as to whether quotas will be imposed to govern oil imports rests with public awareness of this vital situation and in turn the communication of opinion to Congressmen."

As an importer, Jersey Standard informed its stockholders:

"The Congress of the United States has been urged to restrict oil imports into this country. This company has consistently opposed legislation to restrict oil imports. We recognize that a healthy domestic oil industry is vital, and that excessive imports, if continued for any considerable period, could be damaging to it. Jersey believes, however, that artificial restrictions such as quotas on oil imports would react to the industry's own detriment and would be contrary to the best interests of both consumers and the national welfare. In our opinion, the most satisfactory balance between imports and domestic oil production can best be achieved through good business judgment by individual companies within the industry itself. Total imports of crude oil into the United States by Jersey affiliates were almost 15 per cent lower in 1953 than in 1952."

The largest U. S. oil company also pointed out that foreign demand increased nearly 8 per cent and domestic demand almost 5 per cent, both reaching new peaks. "We expect growth in the use of oil will continue," reads the report. "As has been the case in recent years, the growth will probably be at a faster rate abroad than in the United States."

Pan American Petroleum and Transport Company reported that "surpluses were augmented by a reduction in military requirements and by abnormally warm weather during the fourth quarter."

It was difficult for many companies to view imports so philosophically when reduction in allowable producing days cut their production below 1952, which was against the trend. Plymouth Oil Company's report thus explains its drop in crude oil output and consequently in income:

"By far the larger portion of the company's crude production is obtained from within the State of Texas where crude production is under strict control of the Railroad Commission of Texas. During the year 1953, there were only *236* allowable producing days, as compared with *259* during 1952. Of the 23 less producing days in 1953, *16* were applicable to the last quarter."

Small wonder Plymouth devotes considerable space to the problem of foreign oil competition including, "It is obvious that substantial relief from excessive imports, if it is to be had, must come through legislation."

States the Houston Oil Company of Texas report: "Since 1948 when producing days and calendar days were identical in number, the ratio (of allowables in Texas) has gone down until last year producing days were less than two-thirds of calendar days." (Present Texas allowable is 17 days.)

"During the year domestic oil production was severely curtailed under state conservation laws because of a lack of market. Production in Kansas was completely shut down for a period of 10 days during the month of October and for the balance of the year severely curtailed. Other states were also forced to make drastic cuts in allowable production," reports Derby Oil Company.

Contrast between unrestricted imports and regulated domestic production is drawn by the report of Panhandle Oil Corporation: "No one questions our need for some foreign oil nor wisdom of importing it at a rate that is properly related to growing demand and to domestic production, but a more equitable basis of solution must be found than the present unfair unbalance between complete freedom to importers and severe restriction on domestic producers."

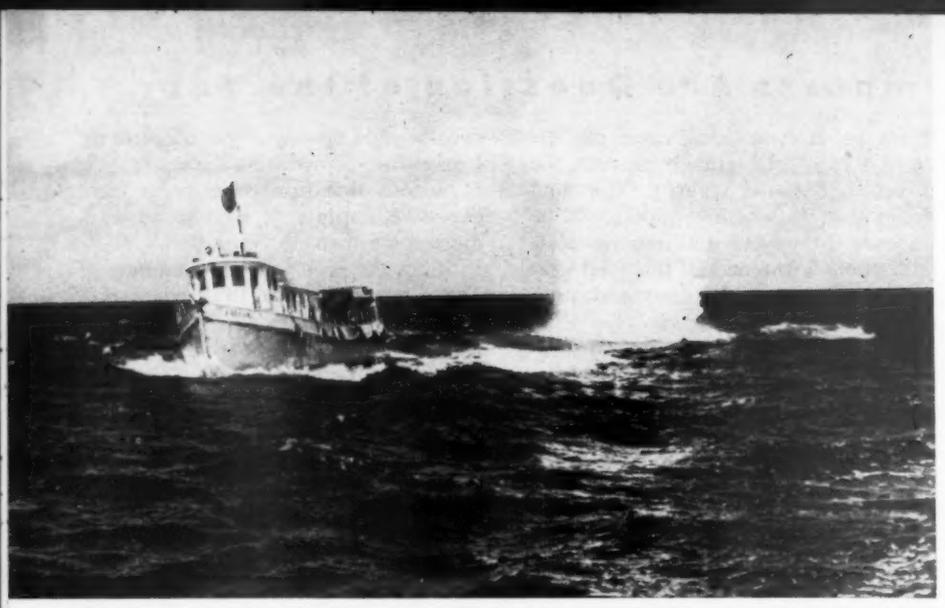
Continental Oil Company recognizes the problem and terms it a swing in the competitive market, caused by over reaction to increased crude prices, but the company concludes optimistically:

"The over-supply situation is a temporary ailment which will be cured in the future — as it has been many times in the past — by the familiar economic remedy of price response to the law of supply and demand. Indications are that, over the long term, the oil industry is facing a healthy and prosperous future."

Price Rise

Undoubtedly the price rise had its effect on exploration, drilling, and production and therefore affected over supply. The Ohio Oil Company calls the "general increase in crude oil prices . . . the year's most significant development in the petroleum industry — it being the first increase since December 1947. California crude oil prices advanced shortly after petroleum prices were decontrolled in February by the Federal government."

Phillips Petroleum Company, which set the increase, reports that it "only partially covered the large increases in costs of finding, developing, and producing oil" and emphasizes:



During most of 1953, Sinclair seismograph crews probed beneath off-shore water for structures favorable to the accumulation of oil. Here, a shooting boat in the Gulf of Mexico explodes a dynamite charge to set the tell-tale sound waves in motion.

Sinclair Annual Report

"The industry continues to produce largely its lower cost reserves, discovered years ago, which are steadily being depleted. In the face of rising costs of finding and producing oil, there is a serious question as to how long the industry can continue to fulfill increasing needs for oil at today's prices. Present crude oil prices are firm; however, continued increases in the current high inventories of gasoline may occasionally create local weakness in the prices of that product."

Not all crudes got higher prices. That the meshing of production, transportation and refining facilities is essential to efficient economy is well illustrated in Amerada's report:

"As in 1952, the market outlet for the North Dakota fields was limited by lack of pipe line facilities resulting in a continuous sub-normal price for the oil. The net production of the corporation in this area has averaged approximately 10,000 barrels daily since late in 1952. The difference between the price of $2.00 per barrel received for this oil and the price of approximately $2.90 for oil of the same quality in most of the producing areas of the United States, is even greater than the 65 cents difference of a year ago, because of a price increase in other areas which was not extended to North Dakota. The pipe line from these fields to Mandan, North Dakota, has been completed by Service Pipe Line Company, and the refinery, with a daily capacity of 30,000 barrels, being constructed at Mandan by Standard Oil Company (Indiana) is expected to be completed in October of this year, at which time an increased outlet and a normal price for this oil are to be expected."

Refined products went up slightly but, The Texas Company stated: "Refined petroleum product prices improved following the advance in crude oil prices, but prospective revenues therefrom were offset in part by increases in wages and other costs and by the effects of sporadic retail 'price wars' in many parts of the country. It is significant to note that from 1947 to the end of 1953 the increase in the average price of all major petroleum products was only 2 per cent."

Anderson-Prichard Oil Corporation reports: "In June 1953 the price of crude increased 25 cents per barrel, which increase partially compensated for the increased cost of finding and developing crude reserves. The price of refined products was advanced to substantially offset the increased cost of crude oil; however, due to abundant supplies, refiners soon cut their prices and in December refined products were only slightly higher than in December 1952."

Cost Increases

Along with price increases costs went up. Humble Oil and Refining outlines the reasons: "Operating costs increased in 1953 as the result of several factors: (1) greater depreciation because an increasing proportion of production is coming from fields with higher investment per barrel of reserves; (2) greater amounts for surrendered leases; (3) additional expense for operating more producing wells and leases; (4) higher rates of pay; and (5) increased ad valorem and production taxes.

"Efforts continue to be made to achieve improvements which tend to reduce costs. For example, a permanent type well completion technique has been devised for working over wells through the tubing by means of special equipment at savings which are substantial and will become larger in the future. This method should reduce the expense of working over wells by as much as one-half in some areas."

Seaboard Oil Company of Delaware reported: "Demand for products increased and crude oil prices advanced. These provided additional funds and incentives for greater drilling and exploratory activities than ever before. However, of the 49,000 wells drilled during the year, 18,000 were dry holes, which demonstrates the difficulty and high costs of finding and developing new reserves. While these activities resulted in net additions to the nation's proved reserves, preliminary reports indicate that they were little more than enough to keep pace, proportionately, with the steadily rising demand for oil and its products."

Despite the difficulties, Seaboard stated it had "substantial success in 1953 in finding new reserves of oil, gas and distillate." Part of this success was discovery of the promising Pembina field in Alberta, Canada.

The primary cause of Delhi Oil Corporation's net loss for the year of 1953 (only loss figure shown in Table 1) was cost of dry holes resulting from intensive exploration activity.

"The average cost of all wells drilled increased from $83,000 per well in 1952 to $140,000 in 1953. This increase resulted primarily from deeper drilling in areas having multiple sand possibilities," reported Union Sulphur and Oil Corporation.

A reminder that the fabulous Williston Basin is still in the red comes from Signal Oil and Gas Company.

The company has been disappointed in operations in the Williston Basin undertaken jointly with other companies in connection with several million acres of leases acquired in the very early stages of development in this basin. Several wells have been drilled by these companies jointly, and in addition, many other wells have been drilled in farmouts of acreage in which these companies own an interest. None of these wells has resulted in commercial production.

The Superior Oil Company puts it succinctly: "Despite the increased revenue obtained in 1953, the costs of production and certain other charges against income exceeded similar expenditures for 1952 to the extent that there was no substantial change in net earnings between the two years."

Deeper Drilling

There is ample evidence of one reason for higher costs: Deep drilling. Most producing companies review briefly their successes in finding new fields and many in this year's reports belong to the deep, expensive type.

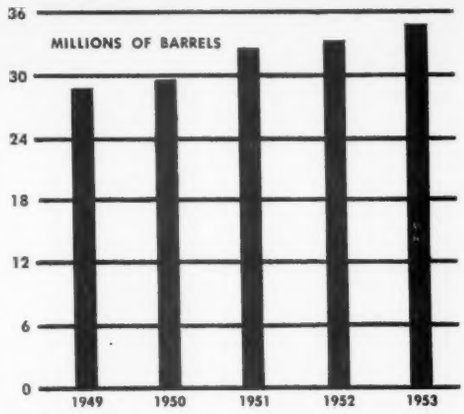
Louisiana Land and Exploration Company explains: "Interest in drilling to deeper horizons has greatly increased. Drilling to deeper levels, of 12,000 feet and more, is no longer unusual."

"An oil discovery well in Vemilion Parish, Louisiana, for a daily flowing potential of 374 barrels at a depth of approximately 12,330 feet," was announced by Houston Oil Company. "Gas-distillate production was indicated in a deeper test at approximately 12,900 feet."

Texas Gulf Producing Company gave as the "most significant development in our picture for 1953 . . . the discovery of the multi-pay Headlee Field, Ector County, Texas, between the towns of Midland and Odessa. The discovery well was completed at a total depth of 13,313 feet after penetrating the Ellenburger formation 237 feet of productive section. The Headlee No. 2 cored 250 feet of productive Devonian section and, below that, approximately 350 feet of Ellenburger before the water level was reached." Ellenburger wells in this field are allowed 485 bbl per day and Devonian about 200 bbl per day.

"Our principal oil discovery of the year," for Pan American Petroleum and Transport, "was made at Boutte, St. Charles parish, southeast Louisiana, . . . At the end of the year, two oil sands and two gas sands had been found at depths between 10,000 and 11,000 feet. There are indications that the field has additional productive possibilities at still greater depths."

Another expensive operation was revealed by Universal Consolidated Oil Company when describing development of a lease in a Los Angeles residential area: "The City of Los Angeles imposed severe limitations and restrictions on drilling and development, including the restriction that all surface operations must be confined to a drilling island, 200 ft by 300 ft, which afford maximum protection for adjacent residential areas. It is planned to develop the property from the drilling island by directionally drilled wells. The discovery well on test produced at a daily rate of 525 barrels."



Oil industry reserves, Continental United States. The aggressive companies are finding oil and plans are for greater effort in 1954. — *Plymouth Oil Annual Report.*

In spite of these difficulties the aggressive companies are finding oil, and plans are for greater effort this year.

Drilling and Exploration Company reported its proved reserves (though small) were up 75 per cent. Argo Oil Corporation stated that as a result of wells drilled in 1953, company reserves of crude oil and natural gas have been substantially increased.

"During 1954 the (Pure Oil) Company expects to drill 60 per cent more wells than in 1953 and of this total one-third will be exploratory."

That paragraph expresses the purpose of a number of companies.

Secondary Recovery

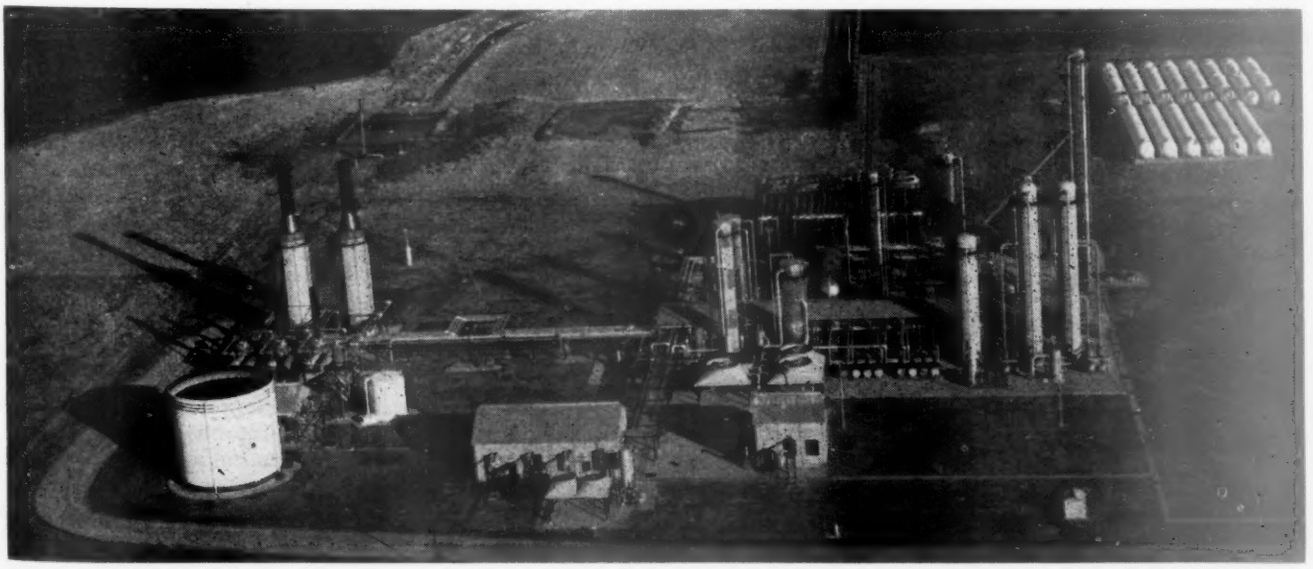
The impact of secondary recovery methods on the oil industry may be glimpsed by Gulf Oil Corporation's statement that its "1953" capital expenditures in the United States for fluid injection were over twice as high as in 1952, and were 8 times as great as in 1951."

Nearly all producing companies have interests to some extent in reviving old fields. Texas Pacific Coal and Oil Company states: "Water flood operations have been conducted on a small scale for the past several years, and a total of $908,110 has been expended ($420,420 in 1953), largely on one lease in West Texas. Through this operation, over 1000 barrels of additional production per day have been obtained. The company owns a number of shallow oil properties that in all probability can be successfully water flooded, and careful study is being given toward extending the scope of this work."

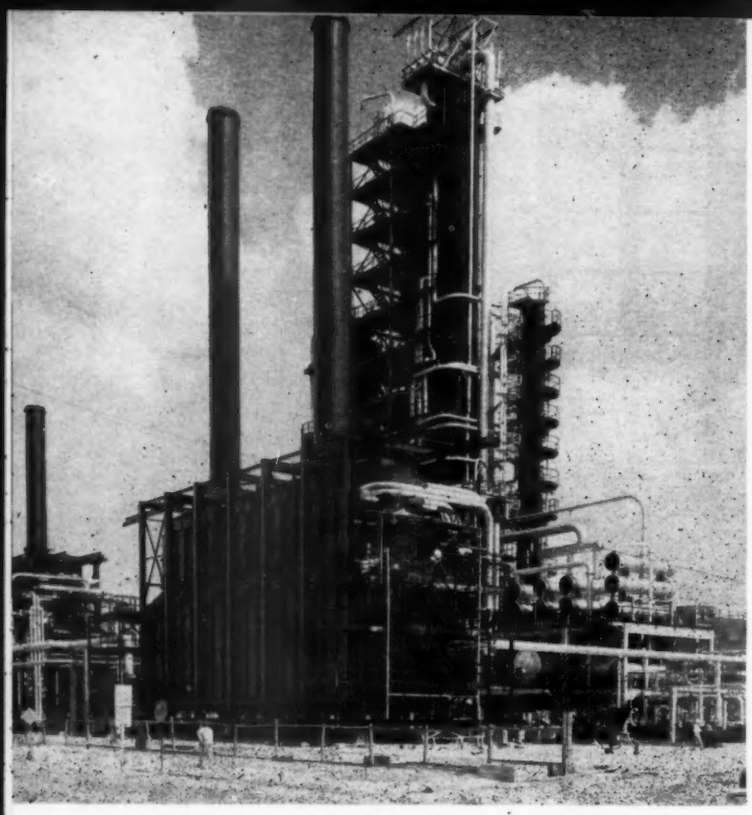
Reports Deep Rock Oil Corporation: "Of particular interest in connection with our record crude oil production is the increasing importance of secondary recovery. The intensive and well-planned engineering work of the past several years is beginning to pay off in increased production."

Owning 12¾ per cent of the Paola, Kansas, water flood project, Maracaibo Oil Exploration Corporation announced a new high return of $91,000 on this property in 1953.

American Republics Corporation reported: "Secondary recovery operations, by water flooding or gas injection methods, were begun during the year and are now under way in the Housh Field, Tyler County, Texas, and in the Merchant Field of Liberty County, Texas. Continuing study is being



Aerial view of new Cities Service Ambrose natural gasoline plant near Blackwell, Oklahoma, extracts liquid hydrocarbons from pipeline gas. Number of gasoline plants has been stepped up by the industry. — *Cities Service Company Annual Report.*



Two pipe stills at Esso Standard's refinery, Baton Rouge, Louisiana, raised capacity to 300,000 bbl a day. *—Jersey Standard Report.*

Cloud-scraping towers of new solvent lubricating plant, is Deep Rock unit. *— Deep Rock Annual Report.*

given to the possible application of secondary recovery methods to other producing properties of the corporation."

Because "results of the water flooding programs on the Sac-Fox unit in Lincoln County, Oklahoma, more than met" Wilcox Oil Company's, "expectations throughout the past year," it acquired more interest in the unit, now owning 77 per cent of the 1470 acres and 119 wells comprising the project.

"In line with modern conservation practices," British-American Company "initiated during 1953 a pressure maintenance project by water flooding on its Steamboat Butte field in Wyoming. Some 15,000 barrels of water per day are now being injected through three flank injection wells in this field. This project is expected to increase the recoverable reserve from one of our most important fields."

Pressure Maintenance

Another method of recovery that has gained favor where practical is the gasoline cycling or repressuring method.

For example, Kirby Petroleum Company is participating 13.65 per cent in the South Hampton Field, Hardin County, Texas. It reports: "A contract has been signed for the sale of gas and it is contemplated that a plant to process the gas and recover the liquid hydrocarbons will be erected in which your company will participate. With the completion of these facilities, the income to your company from this field should be materially increased."

Humble, an advocate of the cycling programs, stated it was engaged in negotiation with other operators in 17 fields for field-wide unitization programs at the end of the year. The annual report read:

"Additional arrangements were completed and others are in progress for unitization and other cooperative programs which will increase ultimate recovery of oil and gas. In the Fort Chadbourne field (Coke and Runnels Counties, Texas) Humble, with a 63 per cent interest, was designated as the operator of a unit consisting of approximately 300 wells with production of more than 15,000 barrels daily. The unit is engaged in a pressure maintenance operation by gas injection, estimated to increase the ultimate recovery of oil from the field by about 9,500,000 barrels. Humble also became a party to the Krotz Springs field unit in St. Landry Parish, Louisiana, in which Humble's interest is 28.4 per cent. This unit will put into effect a cycling program designed to increase the recovery of liquefied petroleum products."

Another company that specializes in unitization projects is Sunray Oil Corporation whose annual report describes one project thus:

"The South Sarepta Unit, Bossier and Webster Parishes, Louisiana, is another project in which Sunray, with approximately a 27 per cent interest, has taken the lead. The field was discovered in May, 1949. The injection program is expected to increase liquid recovery considerably and will permit development of the 10,000-acre field with only one well per square mile. This project necessitated field-wide unitization under an order of the Louisiana Commissioner of Conservation providing for cycling."

A new method of secondary recovery is described in Sinclair Oil Corporation's annual report under "Research—New Frontiers." It reads:

"For over five years, Sinclair scientists have been experimenting—in laboratory and field—with a new method of using underground heat to release such oil so it can be pumped to the surface. Extensive field experiments testing this method were the first of their kind to be carried out by any major oil company. These tests show promise of increasing Sinclair's recoverable crude oil reserves, and of adding to the value of old fields still under lease."

One advantage to the secondary recovery operator is that he is not restricted by allowables but is permitted to produce at the most efficient rate.

Tidelands

Another question the oil industry was glad to see settled was the ownership of the "tidelands." Hancock Oil Company got direct and immediate relief benefit from the bill:

"In May of this year the Congress of the United States passed and the President signed a Submerged Lands Act which, among other things, vested title to the so-called tidelands in the various states . . . Passage of the Act has removed the uncertainty which has sur-

rounded the operations . . . on such properties since June, 1947, when the Supreme Court ruled that the United States held paramount rights to such lands.

"Following the passage of the so-called tidelands legislation the company received a dividend in the amount of $7,445,631 from Southwest Exploration Company (⅓ owned) out of earnings which had accumulated since the Supreme Court decision of 1947."

Kerr-McGee was developing a gas-distillate field in Block 39 Field, Vermilion Area, in the Gulf and its report read: "Anticipating increased drilling activity in the Gulf of Mexico Tidelands areas, a study has been made to determine the need for additional offshore drilling units and the company is now designing a new type of ocean drilling structure. In addition, improvements in design have been completed on the deep water submersible type barge, the use of which the company has successfully pioneered in the Gulf Tidelands area."

Shell, Continental, Pure, Superior, Socony-Vacuum, Humble, and others were preparing for open water drilling in the Gulf of Mexico. Some companies were working off the California coast. Monterey Oil Company reported: "The favorable outcome of recent tidelands litigation cleared the way for Monterey to resume preparations for drilling on a state lease off the Southern California coast. The company is building a drill site one and one-half miles offshore from the City of Seal Beach preparatory to making a thorough test."

TABLE 2. OIL AND GAS OPERATIONS IN 1953

Company	Net lease or fee dev. or undevel. (1000 acres)	Net wells drilled 1953	Net oil and gas producers	Net wildcats	Net discoveries	Net oil and gas wells owned	Net B/D average oil prod. inc. LPG	Daily average gas prod. MMCF	B/D average crude runs 1953	Est. Reserves Million bbl oil	Est. Reserves Billion cu. ft. of gas[1]
Amerada Pet. Co.	13,904[1]	329[1]	225			2,573	77,185			600	
American Republics	907	106[1]	82[1]	17[1]		633[1]	14,304	45			
Anderson-Prichard	457	74	43			982[1]	11,537		19,324		
Argo Oil	512	54	43			229	9,326				
Ashland Oil & Ref.	673	69	37	24		2,765	8,454		110,188		
Atlantic Refining	4,967	269	200	41		3,565	105,179	308	179,812	507	2180
Bishop Oil	169	19	14			303	2,077	1			
British-American		193					20,887		86,570	110	
Cities Service	11,174	452	349	90[2]			109,330	718	240,789		
Continental Oil	9,261	462	342	84	16	5,659	128,908		114,722		
Cosden Petroleum[3]		43	20				1,814		21,846	15	
Deep Rock	783	151[1]	111[1]			2,940[1]	9,055		17,814		
Delhi Oil		56[1]	31[1]			215[1]	1,600	12			
Derby Oil	161	74[1]	45			462	3,385		12,690		
Douglas of Calif.	100	9[1]				41	2,432		14,829		
Drilling & Exploration	76	74	63	14		372[1]	2,310	21			
General American						1,139	13,988			85	
General Crude Oil	462	59	29				10,387				
Gulf Oil	13,722[2]	1,256	997	177[1]			737,447		496,696	9700	
Hancock Oil[3]		50[1]	41[1]						13,000		
Honolulu Oil	1,488	91	63	9		1,008	32,000	51			
Houston Oil	1,471	61	39	14		829[1]	14,406	68			
Humble Oil & Ref.	17,038	898	660	158	37	15,323[1]	391,700	866	244,700		
Husky Oil[3]	371[4]	75[1]	42[1]			149	4,336		4,352		
Kerr-McGee[3]	1,380	31	21			577	2,972		8,046		
Kirby Oil		36[1]	15[1]								
Lion Oil	1,424	94	64			873	18,781	34	23,073	90	4000
Louisiana Land & Expl.							18,636	19			
Maracaibo Oil							807		1,876		
Mid-Continent	1,638	264[1]	190[1,5]			2,341	19,263		58,122	100	
Middle States Pet.	2,211	77	62			771	9,866	48		39	227
Midwest Refineries									7,740		
Monterey	138	29	10	19		301	10,298	9		46	75
Ohio Oil	43,424	602[1]	472[1]	104		13,406[1,6]	97,546	199	37,733	666	2130
Pacific Western	469	37	29			551	11,647				
Pan Am Pet. & Trans.	966		44			751	21,610	66	139,931	192	134
Panhandle Oil	78	29	17	12		423	3,732	12	5,625		
Phillips Petroleum	11,146	676	590	55		13,879	186,300	2,080	229,000	1355	17,890
Plymouth Oil	505[5]	75	43			776	21,161		40,720		
Pure Oil	3,579	136	103			5,464	75,446	176	112,658		
Quaker State		233[5]	146[5]				2,735	7,885			
Richfield	420	125	71			1,206	56,446	136	111,646		
Seaboard Oil		121	82				34,604	88			
Shamrock Oil & Gas	608	65	57	8	1	518	9,498	203	10,476	17	1462
Shell Oil		1,002	834	153	37	8,400	315,362	867	412,000	1200	
Signal Oil & Gas			93[1]			860[1]	47,577	18			
Sinclair Oil	11,483	639	532	76		9,269	140,733	105	414,393	678	1700
Skelly Oil	3,836	388	338			3,985	78,226	311	44,800	351	2,300
Socony-Vacuum							462,720	793	631,560	1650	7,400
South Penn Oil	732	369	170	10	9	13,805	12,026	25	8,687	40	75
Standard of Calif.	32,860	569	456	113	28	7,955	337,880	392	446,604		
Standard of Indiana	15,090	775	606	203[1]	59[1]	10,964	268,090	919	561,000	1953	9900
Standard of N. J.		1478	1324	382			1,838,000		1,915,000		
Standard of Ohio	1,487[7]	139	102	29	7	2,028	30,693	93	133,791		
Sun Oil		529	386	223[1]	83[1]		118,000		222,654	750	
Sunray Oil	2,974	275	197			3,437	73,000	22	89,000		
Superior Oil		232	172				62,373	193		300	
Texas Company	18,804	1747[7]	1373[7]				369,000		543,000	2046[7]	10,500[7]
Texas Gulf Prod.	226	38	26	13		353	9,770	35			
Texas Pacific Coal & Oil	851	116	87	7[1]			19,706				
Tide Water Associated	2,103	212	170	42	9	5,121	99,024	203	181,708	545	1758
Toklan Royalty	83	24	13	9		170	1,033	4		4	21
Union of California	3,963	297	201			3,159	109,760	181	141,243	510	1621
Union Sulphur & Oil	759	31	15	8	1	294	11,878	77			
Universal Consolidated	37	10	6	4		264	2,677	3			
Utah Southern Oil Co.	250						2,653				
Warren Petroleum	1,058	87	64				11,926	49		51	277
White Eagle Oil	182	98	40	51	5	722	3,537	16		11	351
Wilcox Oil	108	31	22	11		355	2,481		4,651		
Woodley Petroleum	85	150[1]	112[1]			491[1]	2,451	3			

[1] Gross. [2] Undeveloped. [3] Report for year ending June 30, 1953. [4] Does not include Israeli permit.
[5] Includes service wells. [6] Undeveloped only. [7] In U. S. only. [8] Report for year ending April 30, 1953.

Manufacturing

Refining methods were changing at a dizzy rate and had a great deal to do with the level of capital expenditures in 1953. Standard of California explained:

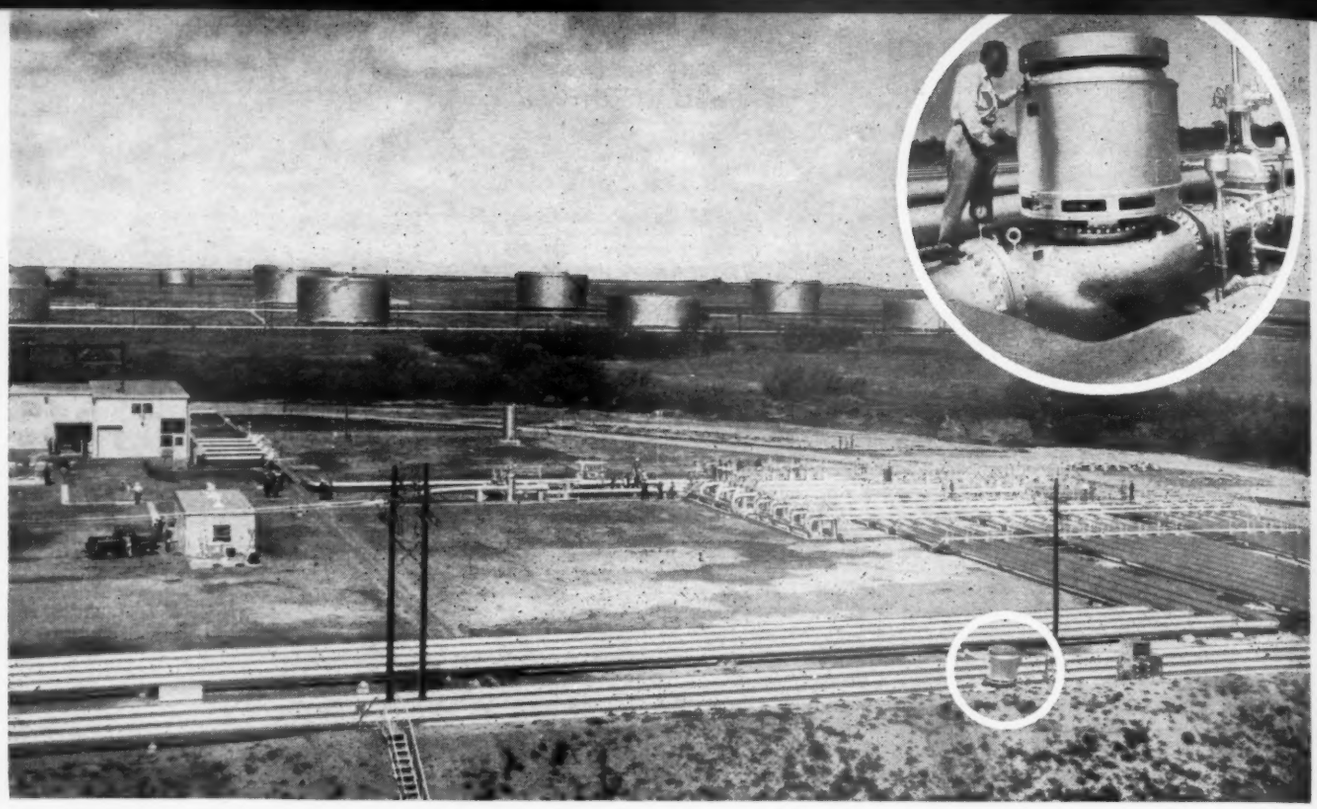
"To meet new demands, petroleum refining processes are becoming constantly more complex and costly. Automotive engines are going to higher compression ratios, some motors requiring fuel equivalent to the aviation gasoline of only a few years ago. Aviation gasoline requirements, too, have maintained a steady uptrend. Lubricants and greases constantly must be improved. As the field of chemicals derived from petroleum broadens, attractive opportunities are found for the installation of new processes and plants.

"For these reasons, the company has been engaged in a large construction program of refinery facilities and chemical plants, and projects amounting to $58,000,000 were authorized in 1953. Actual expenditures will be at a peak during 1954, as some of the projects are completed and others go into major construction phases.

"The various projects are not planned to add substantially to the total of refinery runs. Instead, they will turn out products of more kinds and of higher value."

Cosden Petroleum gives a more specific example of refining modernization in its report:

"You were informed last year that the addition to our Big Spring refinery for production of benzene, toluene, and xylenes would cost $3,600,000. On August 29 we fired the furnace for the fractionating equipment. On September 10 the Platformer got under way. On September 13 the UDEX extraction equipment came on stream. The completed cost was $3,217,774. The shakedown period extended beyond our estimates, but we were not disappointed because this was the first such combination of equipment in the world."



The Mesa and West Texas Gulf pipe lines join at the terminal in Colorado City, Texas. Inset picture shows a pumping unit and indicates large diameter of pipe. This is part of a system owned by Sohio, Cities Service, Gulf, Pure, and Sun.

—Standard Oil Company (Ohio) Annual Report.

Transportation

Pipe line systems grew bigger and longer and some new tankers were giants. Data on transportation have not been added to the tables because of diversity of the kind of figures given in annual reports.

Standard of California, for instance, lists pipe lines built in which it is interested: "The year saw completion and operation, at partial capacity, of the 718-mile Trans Mountain Pipe Line from Edmonton, Alberta, to Vancouver, B. V. Standard Oil Company of British Columbia, Ltd., has an 8⅓ per cent stock interest in this venture.

"Salt Lake Pipe Line Company extended its line from Pasco, Washington, to Spokane, Washington, a distance of 140 miles. The line carries finished products 706 miles from Salt Lake City to Spokane.

"A new 139,000-barrel tanker was placed in operation for service to Hawaii, Alaska, and Pacific Coast ports. The company and its wholly owned subsidiaries own 26 seagoing tankers."

Information from Gulf includes movements: "Deliveries through the domestic pipe line system in 1953, including Gulf's movements through partly owned lines, were equivalent to 55 billion barrel miles, compared with 51 billion barrel miles in the previous year. The volume of oil handled through the field gathering system was approximately the same as in 1952."

Records were made in transportation as well as in other branches: "Socony-Vacuum's domestic pipe line systems again handled record volumes in 1953, transporting a daily average of 567,000 barrels of crude oil and 173,000 barrels of products. "We continued to expand our pipelines, which provide the most economical medium of overland petroleum transportation."

The same trend was reported by Ohio Oil: "Crude oil gathered and transported by the company's pipe lines during 1953 totaled 178,515,710 barrels, an increase of 9.8 per cent over the previous year."

But there were exceptions to the rule. The Standard of New Jersey report stated: "Humble Pipe Line Company had an 8 per cent decrease in deliveries due to the loss of business to competing new pipe lines."

Storage

Over-supply put new pressure on storage facilities, especially for liquid petroleum gas. The increase in gasoline plants has raised LPG output.

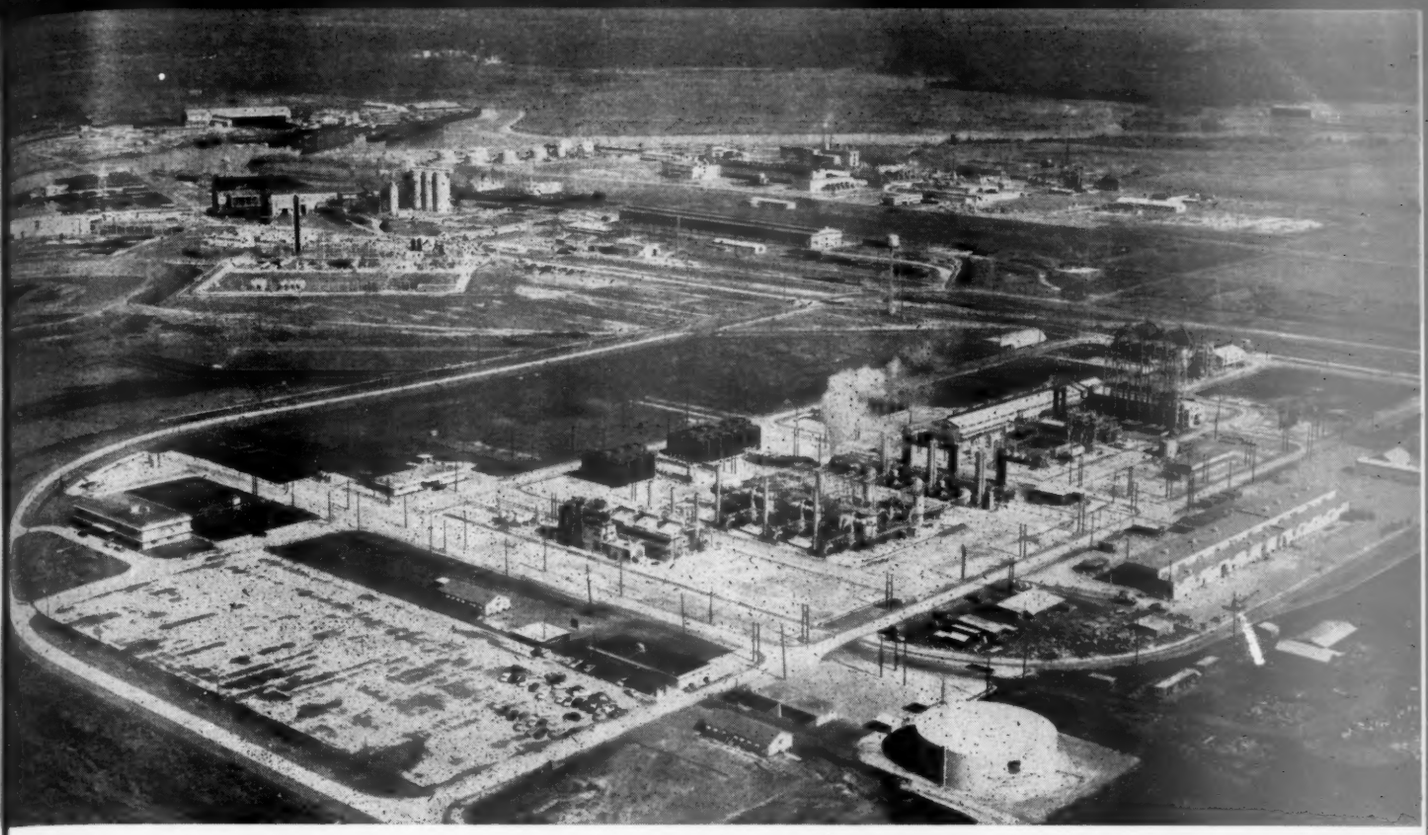
"Shamrock's capacity for the production of LP-Gas (propane and butanes) continues to exceed, during off-peak seasons, the markets for these products. During the preceding year, Shamrock commenced on an experimental basis an operation involving underground storage of excess off-peak quantities of these products at a point near the McKee plant site. This storage reservoir is serving to make available for sale substantial quantities of these liquid products which otherwise would not be available for market except as natural gas. The reservoir has been utilized satisfactorily to store excess production of LP-Gas."

"During the year," reported Skelly Oil, "the company further improved its position as a leader in liquefied petroleum gas. It now has underground storage facilities with capacity of 21 million gallons, hence can store the excess production of LPG during summer months for the heavy winter consumption."

Stated Warren Petroleum: "The

Another 100,000-bbl pressure storage tank being erected at a Gulf Coast terminal is designed for pressures up to 15 psi.

Warren Petroleum Annual Report.



In foreground is new 450-ton a day ammonia plant at Adams Terminal on Houston Ship Channel. In background are (1) new triple superphosphate fertilizer plant (405 tons), (2) expanded ammonium sulphate fertilizer plant (1000 tons), (3) methylvinylpyridine plant, and extensive terminating facilities.
—Phillips Petroleum Annual Report.

corporation continues to provide additional underground storage for liquefied petroleum gas and currently has under construction an additional aboveground terminal for this product at Tampa, Florida. The underground storage program has encountered some difficulties as was expected since it is a novel operation. However, these difficulties have been largely overcome and the program as a whole is expected to afford much greater flexibility and economy in the handling of this product."

Petrochemicals

The advance of petrochemicals as an important part of the industry continued right through 1953 and into 1954. Typical was Continental Oil Company's statement:

"Despite greater competition, sales of products manufactured in the company's petrochemical plants in 1953 were doubled those of 1952. A large part of this growth was made possible by the additions made in 1952 and 1953 to petrochemical plant capacities. Further growth in sales and net income may be anticipated inasmuch as significant parts of the enlarged facilities were in operation during only the latter portion of 1953."

"Petrochemicals offer many new opportunities," reports Standard of California. "The field is highly competitive and the introduction of new products is particularly dependent on research." An example was an isophthalic product to make better paints and plastics.

Research and Products

Probably no industry in the world is so research-minded as the petroleum industry. Tangible benefits are sometimes not apparent or calculable, as South Penn Oil Company admits, but its annual report states:

"The petroleum industry has now come to a full realization that money spent for research is, in reality, investment in its future. In order to reduce capital and operating costs, improve products, develop new products and techniques, and extract the highest ultimate yields from the oil reservoirs, a continuous and coordinated program of research is vital."

Socony-Vacuum has the same idea and explains the lack of more definite reports; "Research is a key to progress in the oil industry, and Socony-Vacuum has continued to emphasize this essential phase of the business. We spent almost $14 million last year developing better methods of finding more oil, of recovering more of the oil we find, and of making better use of the oil we recover.

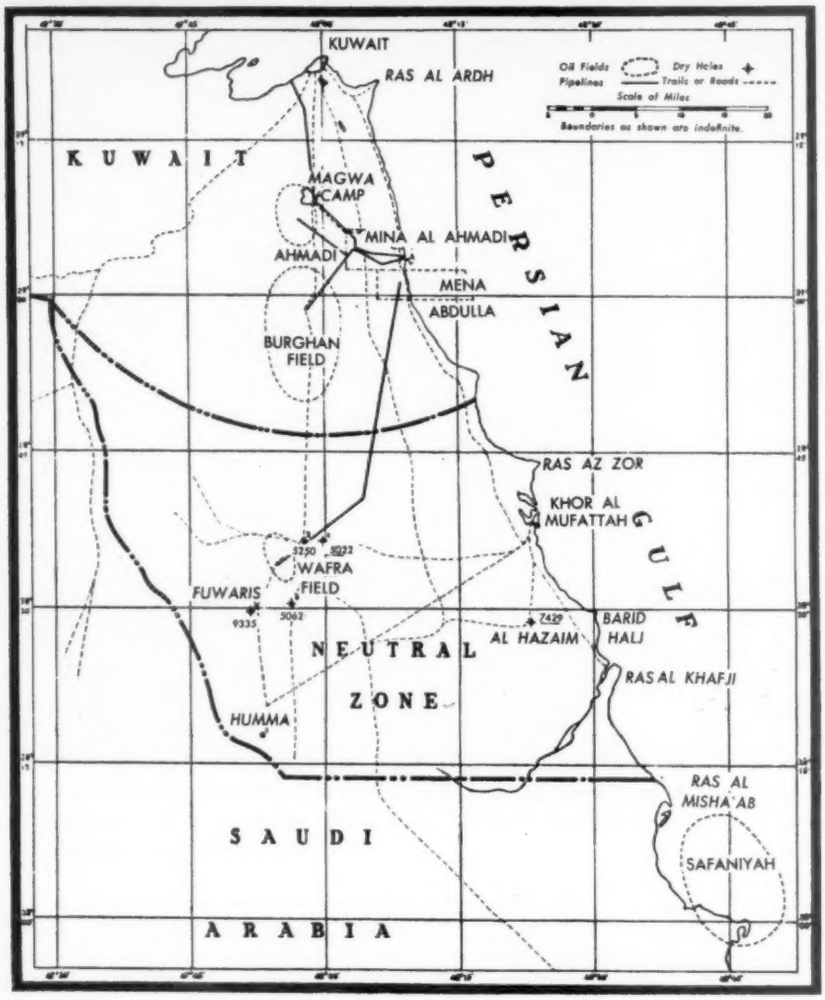
"For competitive reasons, we seldom can report specifically the current work carried on by our scientists and technicians. Many projects continue over a period of years, and it is only when the company announces a new or improved technique, process or product that the tangible accomplishments of our laboratories can be made known."

New and improved products were sought in the chemical laboratories and it looked as if every company made progress.

Douglas Oil Company of California had done well in asphalt products which it sold world-wide: "Substantial capital expenditures for specialty equipment at this refinery during the past several years, backed by an extensive research have diversified these products and steadily increased their sales. Among the many asphaltic specialties . . . are roofing asphalt, automotive specialties, emulsions, cable coating and paper saturants, as well as standard materials used for paving highways and airport runways. Asphaltic specialties now represent 48 per cent of the dollar sales of domestic asphalt compared with 16 per cent three years ago."

In the research department of Mid-Continent, wax got special attention: "The company continues to be one of the country's largest producers of wax and wax specialties, particularly those used by the food and container trade. This necessitates continual research on the part of the technical staff to keep abreast of the changes and improvements required for this very important and exacting market."

There were other results that came



So-called independents entered foreign operations in many countries. Most successful so far is the Neutral Zone concession with an estimated billion-barrel oil reserve in one field.

—Pacific Western Annual Report.

from research. Standard of Ohio developed hollow plastic spherical particles to protect crude oil in storage tanks and reduce evaporation. Gulf developed a household deodorant. Phillips pushed its electronic robot instruments, which use such principles as refractive index and infrared and ultraviolet absorption to control automatically the manufacturing processes.

Lion Oil Company worked toward new petrochemicals based on its raw materials and its report read: "Progress continued on chemicals of interest to the synthetic fiber and plastics industries and in the field of general industrial chemicals. Exploratory work has revealed other interesting possibilities for products which may be developed from both the raw materials and the waste of by-products of the company."

Foreign Operations

The present trend of smaller oil companies entering foreign fields individually and in groups grows each year. Table 2 shows an * before the names of firms having operations, outside of sales, in foreign countries.

Pacific Western Oil Corporation and American Independent Oil Company own 50-50 the "Neutral Zone" concession between Saudi Arabia and Kuwait. They have found at Wafra an estimated billion barrels of Burghan sand oil in place, and, according to Western Pacific's report: "Recoverable reserves . . . are estimated at 429,000,000 bbl by your company's geologist."

Husky Oil Company has a subsidiary in Canada and "Early in 1953, Husky was granted exploration permits covering approximately half a million acres in Israel. Under terms of the permits, drilling operations must commence within two years. In association with others and operating under the name 'Husky International Ltd.,' exploratory work was begun and preliminary results have been encouraging.

"While the company is pleased with the geological results thus far discovered, it is also pleased with the economic and political climate under which it has been able to operate."

General American Oil Company of Texas has branched out into Canada and, with other companies, is in a "Spanish Venture" described in the annual report.

Taxes

As Sun Oil says: "One of the largest obstacles to increased volume and profit in our industry continues to be the exorbitant tax burdens under which we operate. . . . The continuation of federal excise taxes on gasoline is especially to be deplored. Instituted as a temporary, emergency measure, the federal gasoline tax invades the rightful field of taxation of the states and endangers their most important source of funds for highway construction and maintenance."

Mid-West Refineries, Inc., stated in its report: "State and Federal taxes continue to absorb a substantial part of the income of our companies. No other essential commodity is subject to such severe taxes. Taxes on the petroleum industry take so much of the companies' profits and cost so much to collect and administer, that they have been detailed in this report." (See below).

Cities Service points out: "In 1953, the total combined direct and indirect taxes on the operations and products of Cities Service and its subsidiaries were over $200,000,000. This is the equivalent of $51 per share of common stock outstanding, or $9000 per employee."

The excise tax gets another blast from Lion Oil Company: "The tax bill on gasoline alone for the country as a

Mid-West Refineries, Inc. and Subsidiary Companies

Schedule of Taxes — Expensed and Collected for the Year Ended June 30, 1953

TAXES EXPENSED:	
Federal income taxes	$314,611
Real estate and personal property taxes	58,394
Federal transportation tax	39,232
Michigan franchise tax	14,779
Federal insurance contributions act (Employer's contribution)	12,154
State and Federal unemployment taxes	10,268
Michigan motor vehicle registration and license fees	9,839
Miscellaneous	1,590
Total taxes expensed	$460,867
TAXES COLLECTED:	
Federal excise tax on gasoline	$ 778,102
Michigan motor fuel tax	184,699
Federal income tax (employees' withholding)	121,972
Michigan oil and gas severence and conservation taxes	43,153
Federal insurance contributions act (employee deductions)	12,441
Michigan general sales and use taxes	9,748
Total taxes collected	$1,150,115
Total taxes expensed and collected	**1,610,982**

whole added about three billion dollars to the amount consumers paid for gasoline in 1953. . . . No other useful commodity is subject to so severe a tax, now equal to 35 per cent of the average retail price."

British American states that its direct taxes alone are equal to the total amount paid in salaries, wages and benefits to more than 5000 employees.

Wanted: Capital

The phenomenon of the 1953 petroleum industry is the fact that capital was invested at the highest rate in history — higher than immediately after the war, when years of make-do brought wholesale replacements. Of course, at that time, shortages of material and labor put some limitations on expansion.

Last year saw the largest sums spent in one year to find new reserves and buy facilities for the oil companies to stay in business. To Gulf it is the sign of growth: "The capital requirements of a large unit in the petroleum industry seem almost insatiable — another evidence of the dynamics of growth. In 1953 the company expended for properties, plant, equipment, and related assets, the sum of $222 million compared with $193 million in 1952."

Speaking of the $238 million spent in 1943 Shell reports: "This is the largest capital investment your company has made in any single year and it reflects the substantial development program, including physical equipment such as new plants, pipe lines and service stations, and the wide-spread exploration and drilling activities directed toward the establishment of increased crude oil reserves. As it looks now, this high level of capital expenditure will continue through 1954 and 1955, with some tapering off expected thereafter."

That "tapering off" has been predicted before but there has been little evidence of slackening since 1946.

The necessity of heavy capital expenditures is explained in the report of Tide Water Associated: "Initial steps have been taken toward a long range, coordinated program to increase the company's reserves of crude oil and natural gas, to modernize its refining facilities, and to improve the company's marketing position consistent with economic and competitive conditions. The implementation of this policy will require, over the next few years, substantially increased capital expenditures. It, therefore, may become advisable to retain and reinvest in the business a greater portion of current cash earnings than has been done heretofore. Such a program should ultimately result in greater earnings and values."

Improvement in production, earnings, and reserves of Middle States Petroleum Corporation is credited to added capital expenditures and the cost of enlarged exploratory activity is confidentially predicted, in its annual report, to bring further improvement.

Standard of Indiana gives explicit reasons for increasing capital expenditures despite the industry's excess capacity. Briefly, they are:

1. To hold the margin of unused production capacity for an emergency and to develop new reserves for use.
2. To keep up search for new reserves because relaxing effort would make it difficult and expensive to make up for time lost.
3. To improve manufacturing and marketing facilities because to lag behind in the competitive race for product quality would be disasterous.
4. To expand and modernize now when costs are high requires more funds because depreciation and depletion allowances do not provide the money to replace old facilities. Book value of Standard of Indiana's properties (cost less depreciation) has more than doubled since 1946 but average capacity increase has been little more than 50 per cent.

Another company that is expanding is Standard of Ohio: "Like the industry, Sohio expects to shift emphasis to manufacturing higher quality products, increasing and conserving supplies of raw materials, and reducing costs. We expect to do this in several ways — through large new capital investment, expanded research and development, and continued use of new and improved management methods."

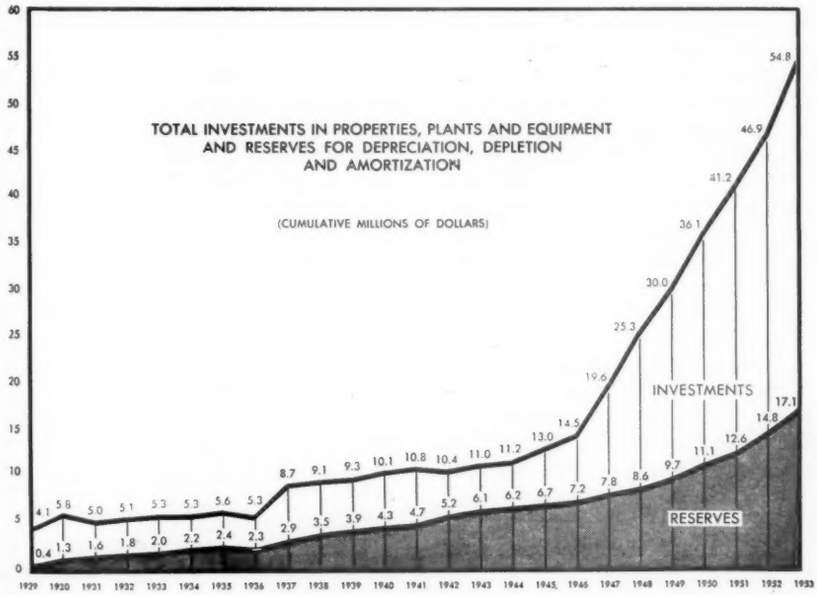
Based on proposed expenditures for 1954, this year will see some $4½ to $4¾ billions spent for facilities needed to keep in business.

Competition

There is one effect of over-supply that was a big force in 1953 and may be even more important in 1954. It is heavier competition.

The petroleum industry is wooing the customer with the most fabulous products in history. Price in recent months has stabilized but the sky is the limit on quality. The consumer's surety of value in a free market was never more pronounced.

Continental Oil predicts that competition will grow: "As was predicted



Despite some short-term depreciation certificates, tax allowances continued far below replacement costs. Reserves here are less than one-third capital investments in recent years and these inxestments are mounting.

—Shamrock Annual Report.

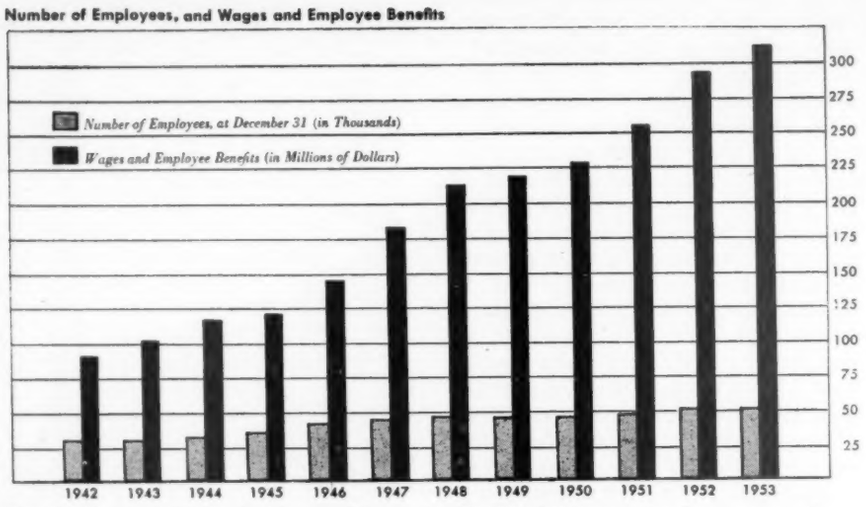
Income for First Quarter 1954

Company	Gross income ($1000) 1954	Per cent of 1953	Net income ($1000)	Per cent of 1953
Ashland	62,306	99	2,040	70
Atlantic Refining	162,445	99	11,025	99
British American		115		
Continental Oil	124,473	116	11,608	116
Drilling & Exploration	2,047	121		
Gulf			38,128	107
Honolulu	7,383	105		
Houston Oil	8,477	103	1,766	92
Lion Oil Company	26,285	113	3,469	122
Plymouth Oil			1,920	84
Phillips	198,500	108	19,162	108
Quaker State			446	85
Shamrock	8,745	108	1,803	120
Shell			33,197	130
Skelly Oil	52,237	100	7,165	99
Standard (N. J.)			146,000	116
Standard (Ohio)	75,228	99	4,461	111
Superior*	19,034	110		
Texas Company			50,848	119
Texas Gulf Prod.	3,260	129	1,512	172
Texas Pacific			2,072	112
Union of California	89,736	119	8,445	107
Warren	89,680	99	6,387	84
White Eagle	3,264	155		

*First quarter ended November 30, 1953.

First quarter income shows results of improved prices and end of excess profits tax.

XUM



Typical is the steady rise in employment and the sharp increase in wages and benefits shown in this chart. Several companies now pay more than three times what they did 10 years ago to employees. — *Standard Oil Company (Indiana) Report.*

in last year's report, competition in the oil industry was accentuated in 1953. Even more intense competition may be expected throughout 1954. Efficient management and low-cost operation will continue to be requisite for success in our industry."

Agreeing with this view is The Texas Company, which states: "The year witnessed an increased intensity in competitive conditions. Advertising and sales promotion efforts have been stepped up as part of an over-all accelerated sales activity. Research activities have been directed toward further improvement of products, as well as methods for finding and producing crude oil."

Cheerfully Woodley Petroleum looks at the situation with this to say: "In the opinion of many, we have moved from a 'seller's market' into a 'buyer's market.' This conclusion is suggested by some of the necessary adjustments being made today. If so, it is not unfortunate that competition, the genius of our American system, is again with us in a more imposing form. This condition presents a real challenge to us all and forecasts good health for business and precious insurance for our competitive enterprise system of which we are so proud."

Another company with a good word to say for competition is Atlantic Refining: "Signs of increasing competition were everywhere apparent, and this trend will accelerate rapidly. We believe that the growing intensity of competition is altogether to be welcomed. It is good for the industry because it brings about higher productivity and faster technological progress, and it is good for the public because it brings about greater productivity and faster technological progress, and it is good for the public because it assures consumers better products at lower prices than would otherwise be the case. To the stockholder, it means a company strengthened and made more efficient by its effort to maintain or improve its position."

Pure Oil believes the opportunity was never greater. Its annual report states: "A greater sales effort, improved products and sound planning is needed by business units to maintain position in the more competitive market that is ahead. It is equally true that competition stimulates improvements, increases research and lowers costs, all resulting in increased benefits to the consuming public. We believe the opportunity for responsible enterprise in this country was never greater. It can be realized under a free economy."

Each company manages to convey to its stockholders that it is in a good competitive position. The challenge of competition seems to stimulate the industry's purpose. British-American reveals the pace: "Continued growth is anticipated in 1954. Crude oil production, manufacturing activity and sales volume are expected to continue their upward climb. Keener competitive conditions seem inevitable but your company is confident of its ability to move forward."

Faith in the future comes also from White Eagle Oil Company: "We are confident that our company will outperform the industry average and show greater progress in the competitive times to come than it has in the lush post-war economy."

The Outlook

As Standard of Indiana states: "While our industry is so competitive that earnings cannot be predicted with any certainty, we are fortunate to be in a business that can look forward with confidence to another increase in domestic demand. The increase probably will be almost as large as that for 1953, which is estimated to be between 4 and 5 per cent for the industry as a whole."

In spite of over-supply, Quaker State Oil Refining Corporation has this to say: "The history of the oil industry bears out the fact that a condition of over-supply usually is of short duration. New oil production declines rather rapidly and, unless new sources of supply are constantly uncovered, the total supply will soon decrease."

Houston Oil goes back to imports as the basis for the 1954 outlook: "The need for imports as a supplement to oil produced in this country is recognized, but we are of the firm opinion that imports in the volume to curtail domestic production and slow down the search for new reserves are not in the best national interest. Developments in the import problem will have substantial bearing on what 1954 holds for your company."

The same idea influences Ohio Oil Company's view of 1954. Its report reads: "It is generally believed that business activity in 1954 will average somewhat lower than 1953. It would appear then that domestic demand for petroleum during 1954 should increase by not more than four per cent, and exports may continue to decline. With this prospect, refinery operations must be moderately increased to meet requirements, although yields of gasoline should be reduced if excessive inventories of this product are to be avoided. Unless another sizable gain in crude oil imports takes place, a moderate increase in domestic production may also be reasonably expected."

Using another basis for calculation Anderson-Prichard comes up with a higher estimate for domestic demand.

"Excellent data on the number of petroleum consuming units such as automotive equipment, trucks, locomotives, oil burners, space heaters, etc., is readily available. Based upon this information, domestic demand for petroleum products in the United States for the year 1954 is expected to be about 6 per cent higher than in 1953. However, it must be borne in mind that a substantial decline in business activity would immediately reduce the demand for industrial oils, and also that a reckless increase in the importation of foreign crude oil and petroleum supplies could deprive the domestic industry of all the benefits of increased competition."

Bishop Oil Company sums it up: "The petroleum industry in recent years has been remarkable for its self-discipline and there is every hope that imports soon will be brought into balance with domestic production." * *

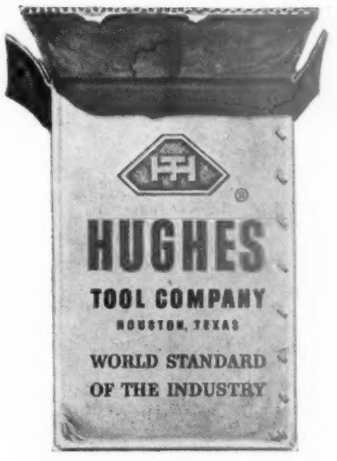
XUM

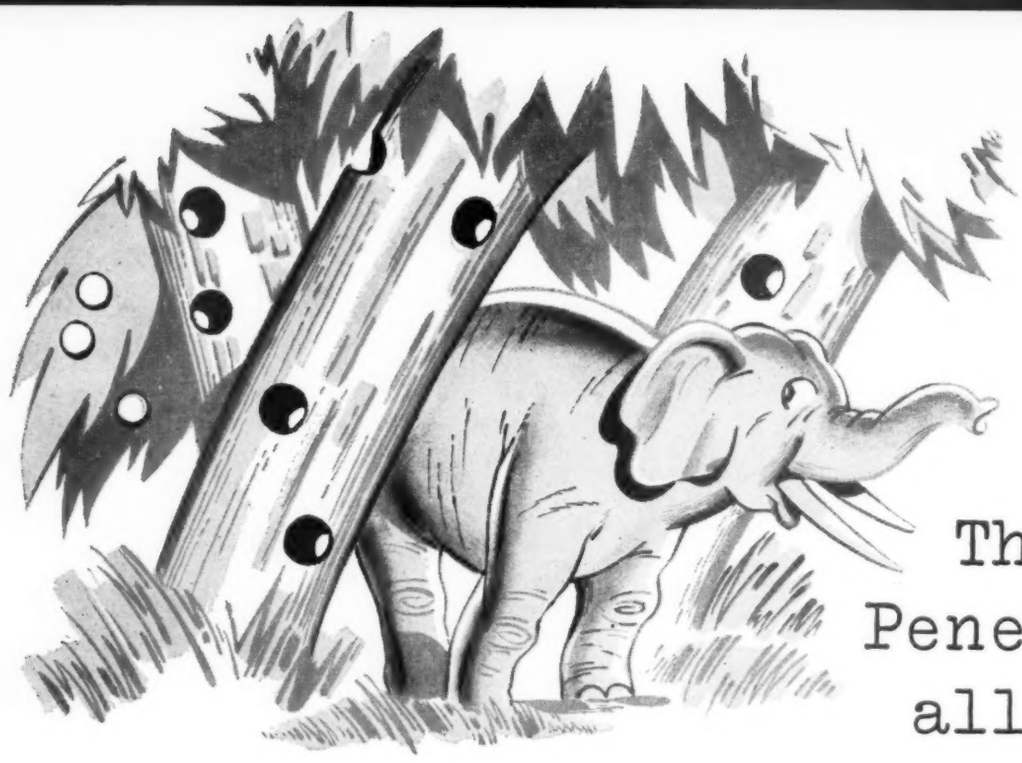
We're drilling on Iron

to learn more about bearings

Bits are being run on heat-treated alloy steel blocks in the continuous and exhaustive bearing tests now in progress in the Hughes Laboratory. The steel blocks prevent the bits from making hole too fast, yet permit the stresses and irregular bearing loadings that occur in actual drilling to be simulated. In these tests, the bits are run under extreme loads and at specified rotary speeds, with drilling mud circulating through the drill stem.

Because all phases of the tests can be closely controlled and duplicated, we are provided with an accurate basis for measuring comparative results and for better evaluating bearing performance. This study is only one of many rock bit research projects in progress at Hughes looking to the constant improvement of HUGHES rock bits.



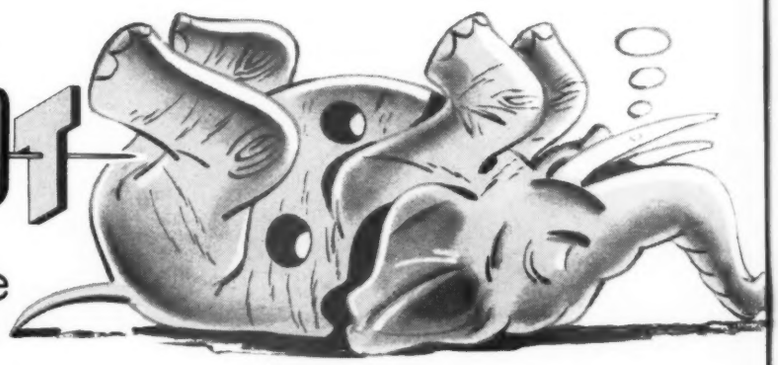


This is Penetration, all right-

but here's

KONESHOT

shaped charge perforating



Koneshot is Penetration plus Control

CONTROL through the *accuracy* given by Lane-Wells famous depth measurement system.

CONTROL through *new detonating devices* which insure against misfires and duds.

CONTROL through *full range equipment*, fitting guns and charges to the conditions of the job.

CONTROL through *advanced safety procedures*, safeguarding your well and your crews.

And, first and last, that DEEP penetration you want so much!

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Peruvian Exploration

Under joint U. S.-Canadian auspices, a new oil exploration program is planned for Peru, east of the Andes and near the navigable headwaters of the Amazon on what is known as the Santa Clara structure.

Peruvian Oils and Minerals, a Canadian firm, is entering into an agreement with Compania de Petroleo Ganso Azul Limitado, a subsidiary of Texas Gulf Producing Company, which will drill one of the series of known anticlines, established by aerial and ground reconnaissance.

Equipment will be moved from Texas Gulf's Ganso Azul properties 150 miles to the south to Santa Clara so that the work can begin with minimum delay.

★ ★ ★

India Well at 10,000 Ft

Assam Oil's new well in the Nahorkatiya area of the Bramadutra Valley is producing at the rate of about 500 bbl a day from its plugged back depth. This test, India's deepest, drilled originally to near 10,000 ft. Operators are proceeding with development, the second and third locations being staked.

★ ★ ★

Rock Formations Mapped

A geological map showing distribution and character of various rock formations in a 180-square mile area of the eastern part of the Los Angeles Basin, has been published by U. S. Geological Survey. Copies of the map, No. OM154, may be purchased from the Geological Survey offices in Los Angeles and Denver, or by mail from the Chief of Distribution, Geological Survey, Washington 25, D. C. Price of the map is 75 cents.

★ ★ ★

Nevada Well Drilling

Announcement of continued drilling in Shell's important Nye County test is received with two additional locations announced. At last report well was below 8250 ft, having pierced more than 1000 ft of volcanic sediment, some fresh water lime, and being bottomed at the time in tight lime. Interest in the test continues high. Leasing of government land in Nevada sets all-time record with more than 7,500,000 of the available 65,000,000 acres assigned, and applications being processed at a high rate.

Gulf Oil Awards

Announcement has been made by Gulf Oil Corporation that 3424 veteran employees in their various domestic departments will be given service award emblems this spring. This will make a total of 16,625 active employees who have participated in the Service Awards Plans, giving Gulf 48 per cent veteran employees with ten or more years service.

★ ★ ★

Arizona Oil Production

Shell Oil has what appears to be a producer in Apache County, northern Arizona, in the East Boundary Buttes area, only 1¼ miles from the Utah line. If it proves commercial it will be the first oil pay for the state. Drilled to 6490 ft, hole was plugged back to 5045 ft, and casing perforated at 4884-4944 and 4963-73 ft. After acidization with 2000 gal, the well blew an estimated 2,000,000 ft of sweet gas with spray of oil.

★ ★ ★

Pembina Reserves

Reserves of Alberta's new Pembina field are estimated between 762,000,000 and 952,960,000 bbl. These estimates of recoverable crude make it Canada's largest field, and exceed the 500,000,000 bbl at Redwater, 40 miles northeast of Edmonton, long regarded the country's biggest.

★ ★ ★

Neches Bid Highest

Bascom Giles, State Land Commissioner for the state of Texas, has announced that Humble Oil and Refining has offered 90.5 per cent of all oil and gas produced, plus a $6000 cash bonus for 65 acres in Anderson and Cherokee counties. This is believed to be a world record oil lease bid.

★ ★ ★

Drill Fluid Film

The Production Division of API announced it has a new motion picture, "Rotary Drilling Fluids" available for industry use. Film is designed solely to supplement courses or discussions on rotary drilling fluids.

Produced by the University of Texas, it was validated by both API and AAODC. In sound and color, the 16-mm picture is 37 minutes long, and deals with control and testing of drilling fluids during operation.

Producing Subsidiary

Formation of a producing subsidiary has been announced by Texas Gas Transmission Corporation. Offices of the new company, Texas Gas Exploration Corporation, will be on the 20th floor of the Melrose building in Houston.

W. M. Elmer, in addition to his duties as vice president and treasurer of Texas Gas Transmission, has been named president of the producing subsidiary. B. C. Adams, Jr., serves as vice president, Fred Schall is chief geologist, and Duncan Foulds, chief production engineer.

★ ★ ★

Lime Field Forum

The Texas Petroleum Research Committee will sponsor a symposium on East Texas Deep Lime Fields in Tyler, Tyler High School, May 7. Conference will be opened by Hon. William J. Murray, Jr., member of Texas Railroad Commission. Impressive list of speakers and their topics promises complete and practical coverage of the subject.

★ ★ ★

Pacific Coast API

Two addresses of general interest will be given on opening day of API Pacific Coast, Production Division, by J. R. Suman, Standard Jersey; and Raymond G. Moley, *Newsweek* feature writer. Technical papers to be presented include discussions of corrosion control in pumping wells, cementing, offshore drilling problems, and well logging as well as a study of core damage from drilling fluids and performance reports from two California oil fields. Dates are May 6-7.

★ ★ ★

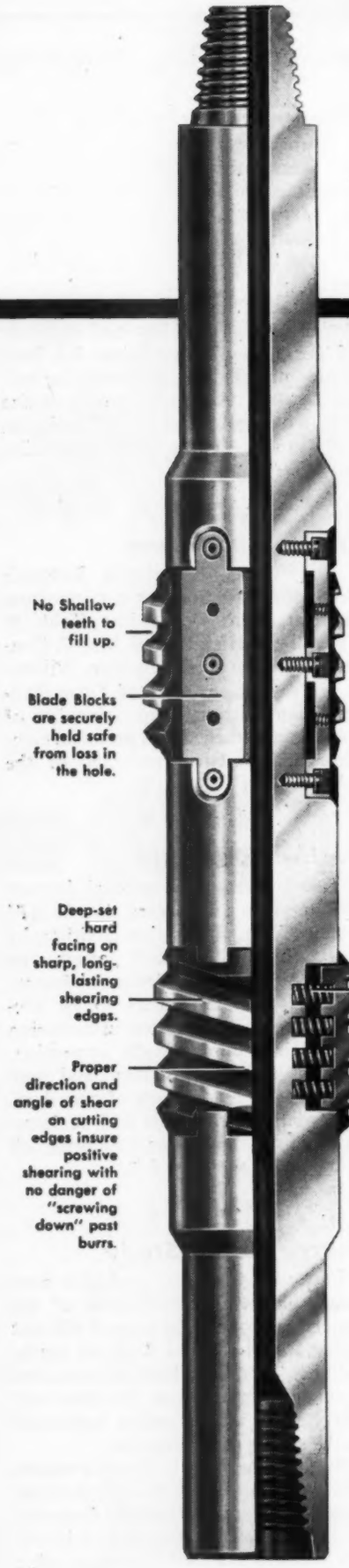
Source Rocks Study

Carter Oil Company geologists have made successful identification of the source rocks of certain types of oils and asphalts in the Uinta Basin of northern Utah. If similar identifications can be made in other areas, this discovery may resolve long standing arguments on the source of oil deposits.

By knowing how to identify source rocks, geologists may be able to locate areas which are particularly favorable to oil occurrence. If source rock identification proves successful in areas other than the Uinta Basin, a new approach to oil exploration may be seen.

How important is it to have the inside of your

casing smooth a


No Shallow teeth to fill up.
Blade Blocks are securely held safe from loss in the hole.
Deep-set hard facing on sharp, long-lasting shearing edges.
Proper direction and angle of shear on cutting edges insure positive shearing with no danger of "screwing down" past burrs.
Springs hold scraping edges in positive contact with wall of casing.
Six Blade Blocks provide 360-degree contact, and stabilize for smooth rotation.

Not only is it important to have clean casing *when a well is being completed,* but consider also the advantages of being able to *proceed safely with any future down-hole work,* knowing that the vital "working surface" (the I. D.) of your casing is *clean and free of all obstructions.*

Hardened mud or cement, burrs from gun-shot perforations, and even mill scale are all hazardous when you run testers or swabs, or undertake to set cement retainers, bridge plugs or packers.

With a Baker Model "C" ROTO-VERT Casing Scraper you can quickly, safely and economically remove harmful obstructions from the inside of the casing, leaving it clean and smooth for any future down-hole operations.

RUN A ROTO-VERT WHEN DRILLING OUT

The best time to use a ROTO-VERT Casing Scraper is when drilling out cement, by running it as a "follow-up" behind the bit. It is recommended that the ROTO-VERT first be lowered through the perforated area *without rotation,* to dislodge any possible imbedded bullets; then raise the Scraper above the perforated area and rotate down the hole and complete the work of drilling out cement. In a *single run* you not only "drill out", but at the same time remove all hardened cement, mud, burrs and scale which might otherwise later *damage swab or tester rubbers* and cause packers, bridge plugs or retainers to *set prematurely*—or *never set at all.*

ROTO-VERT SUPERIOR IN DESIGN AND PERFORMANCE

No other casing scraper can equal the results obtained by the Baker ROTO-VERT, because . . .

1. The *direction and angle of shear* of the cutting edges is OPPOSITE TO THE DIRECTION OF ROTATION. There is no possibility of "screwing down" past obstructions during rotation;

2. The shearing edge of the Blades on the ROTO-VERT is set at *only a slight angle from the horizontal.* This minimizes torque and vibration, and places far less strain on the Blade Blocks and the entire assembly;

3. The six rugged Blade Blocks are positioned to overlap for full 360-degree scraping coverage.

For consultation and service on Baker ROTO-VERT Casing Scrapers...

call BAKER

h and clean?

With these features you are assured that all coatings and obstructions are scraped away and completely removed. No bullets or burrs are left—no hardened cement remains to present hazards to future operations.

ROTO-VERT CAN ALSO BE RUN ON TUBING OR A WIRE LINE

On old wells (or where rotary equipment is not present) the Baker ROTO-VERT Casing Scrapers can be run on tubing, or on a wire line equipped with sinker bars and jars. Spudding action usually quickly removes hardened cement, mud or other coatings WITHOUT ROTATION and clears up any rough or stubborn tight spots. While imbedded bullets usually are dislodged, and burrs smoothed up, "spudding" cannot be expected to give results equal to those obtained by "rotary shearing" of metal obstructions.

EASY AND ECONOMICAL TO RUN

The Baker ROTO-VERT Casing Scraper is readily used by any experienced driller. No service man is required, and the low rental cost is returned many times over in averting future damage to swab rubbers, and to packing elements on bridge plugs, retainers or packers. Elimination of future delays, and re-run expense is also an important consideration.

BAKER OIL TOOLS, INC.

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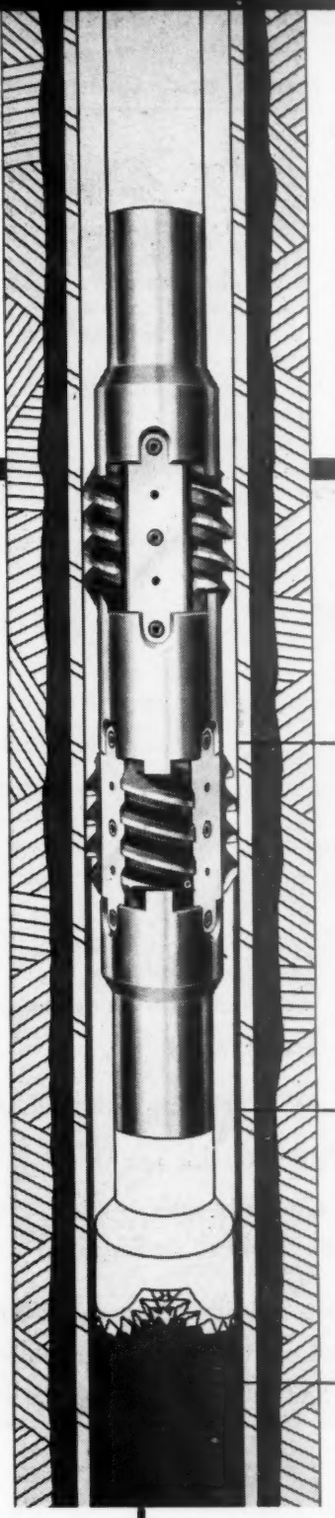


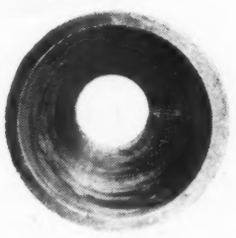
Even when a maximum gauge bit is used for drilling-out, a thin sheath of hardened cement remains to interfere with future operations. To visualize how ROTO-VERT removes this sheath, see left.

All cement, scale, burrs, etc., have been removed by the ROTO-VERT Scraper, and the vital "working surface" of casing is left clean and smooth.

This thin sheath of hardened cement always remains after the bit has passed.

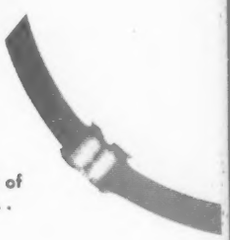
Cement to be drilled out.

This packing rubber would not have been ripped by a gun-shot burr if a ROTO-VERT Scraper had been used.

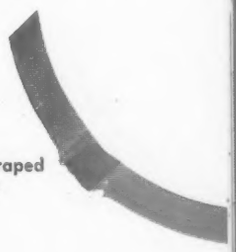


Here's how ROTO-VERT shears away dangerous burrs and leaves the casing safe for all future operations.

The brittle cement sheath (above) prevents the slips of pack-off tools from gripping the casing. See (at left) how slips tried, unsuccessfully, to set against the cement sheath.



Burrs like this can cause plenty of trouble, unless . . .



. . . they are sheared and scraped smooth with the ROTO-VERT.

XUM

Bolivia Shows Made

Glenn McCarthy, Inc., reports gas-distillate production in its first drilling venture in Bolivia.

On a one-hour test the company's first well in Bolivia recovered six bbl of 51 gravity oil and 125,000 cu ft of gas per bbl from a depth of 2115 ft.

Shows of oil and gas were gauged at other depths. This well is near another abandoned 2½ years ago by Y.P.F.B., Bolivian government oil agency because of high gas pressure.

SEG Contest Winner

Winner of the first annual student essay contest sponsored by the Society of Exploration Geophysicists is Gerhard Lukk, 26, a native of Estonia and a student in physics and mathematics at the University of Toronto, Canada. Lukk received the cash prize of $150 from Fred J. Agnich, of Geophysical Service Inc., Dallas, Texas, chairman of the student essay committee, during the joint meeting of exploration scientists at Kiel auditorium.

Denver Offices Open

Calvert Drilling, Inc., has opened a Rocky Mountain division office in Denver, Colorado, with Raymond B. Kelly, formerly exploration engineer of Richardson and Bass, as manager. Two new rigs have been purchased for use in the Denver Julesburg area for 4500 to 8000 ft drilling. Calvert also operates in North Dakota, Oklahoma, and Illinois. Kelly had been with Humble Oil and Refining Company.

★ ★ ★

California Oil Wells

Two California operators have recently announced successful drilling activities. Tide Water Associated Oil Company has completed a new oil well in its Ventura Avenue field near Ventura, California. Flowing 580 bbl of 33.2 deg oil and 335,000 cu ft of net gas daily on 40/64 choke, McGonigle No. 35, producing from a depth of 12,190 to 13,000 ft in the lower D-7 zone.

Union Oil Company Spieler 8-26, operators' third well in the new producing area north of the Guijarral Hills Field in Fresno County, came in flowing 1000 barrels a day of 38.8 gravity crude oil, in Los Angeles County, Union's Sansinena 8B-5 was completed for flowing production of approximately 650 bbl a day of 27.3 gravity crude oil.

★ ★ ★

Depletion Bill Pending

Senator Williams, Republican, Delaware, and Senator Aikens, Republican, Vermont, bill to cut oil-gas depletion allowance from 27½ per cent to 15 per cent is still pending in the Senate Finance Committee. Treasury Secretary Humphrey appeared before the Committee recently, but gave no indication of his attitude on the oil-gas depletion allowance or on the amendment.

★ ★ ★

AAODC Chapter

The fifteenth regional chapter of the American Association of Oilwell Drilling Contractors, has been organized in Abilene, Texas. Forty-six representatives of drilling firms in the West Central Area were present.

After short talks Karl L. Kellogg, Brad Mills, and W. L. McClusky on aims and accomplishments of AAODC, B. F. Gilchrist, Gilchrist Drilling, was named chapter chairman for 1954.

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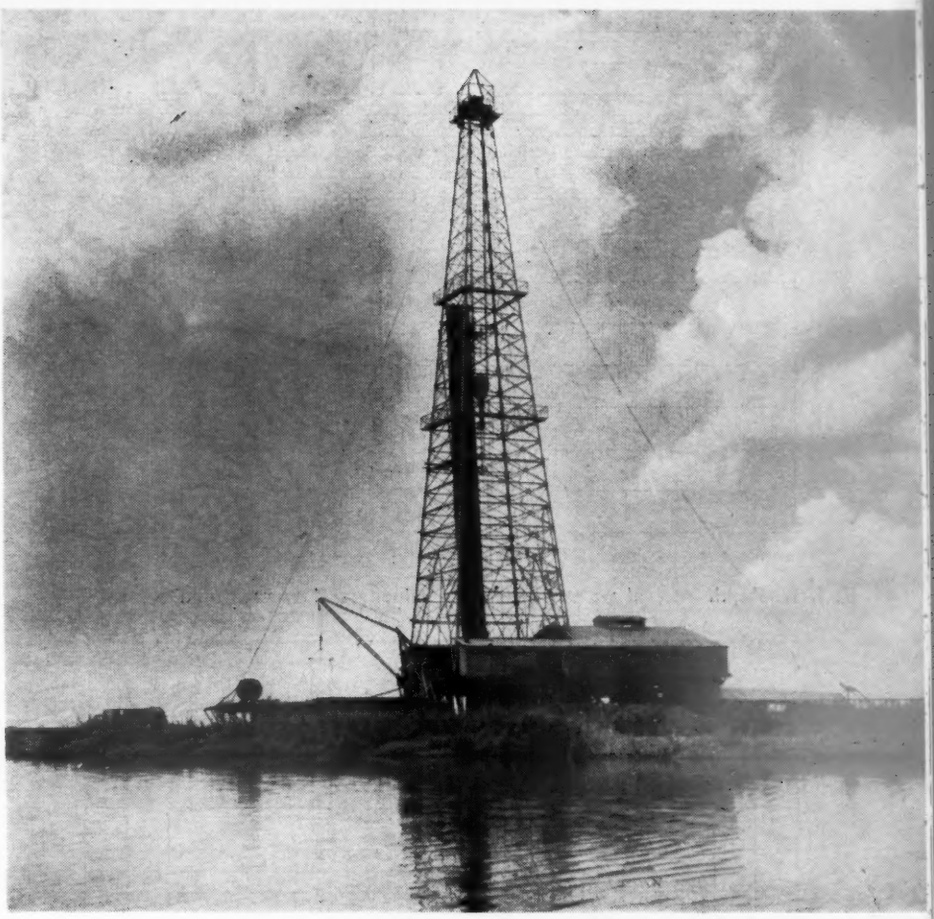
Week's Island

Jet bits used in conjunction with low solids muds and high nozzle velocities speed penetration rate in this deep South Louisiana well . . . . . At right is Shell Rig No. 7, which drills the super-wells in famous Week's Island



P 420

Drilling Speeded in Deep Well Operations

J. E. ATKINSON

SHELL Oil Company's Gonsoulin-Minvielle-State Unit No. 2, Weeks Island field, Iberia Parish, Louisiana, was officially completed October 2, 1953, as the world's deepest commercial producer. Production is from perforations 17,260 to 17,306 ft in a lower Miocene sand. On the initial test the well flowed at a daily rate of 4,293,000 cu ft gas, and 141 bbl of condensate with a flowing tubing pressure of 5800 psi. Prior to completion of this well the producing depth record was held by Shell's Weeks-Gall Unit 1 No. 1, approximately 3000 ft to the west of Gonsoulin-Minvielle-State Unit No. 2. Both of these wells produce from the same sand, but the producing sand is approximately 150 ft structurally lower in the Gonsoulin well than in the Weeks-Gall well.

Gonsoulin-Minvielle-State Unit No. 2 was drilled to a total depth of 18,568 ft in 143 days. By way of comparison, 150 days were required to drill Weeks-Gall Unit 1 No. 1 to a total depth of 17,183 ft. The Gonsoulin well reached 17,187 ft in 83 days. Both of these wells were drilled with the same rig and personnel, and neither well experienced time consuming difficulties, such as long fishing jobs, severe lost circulation, etc. Jet bits were used almost exclusively in drilling both wells. Rotary rpm and bit weight varied in both wells according to depth, but for any given depth interval the average rotary rpm and the average bit weight were essentially the same in both wells.

The impressive reduction in drilling time in Gonsoulin-Minvielle-State Unit No. 2, as compared to Weeks-Gall Unit 1 No. 1, can be attributed primarily to increased personnel experience and higher nozzle velocities. The higher nozzle velocities were achieved by the careful selection of mud pump liner sizes and bit jet sizes to get the maximum benefit from the available horsepower, and by the use of more fluid,

EXCLUSIVE

The Author

J. E. Atkinson is division mud engineer for Shell Oil Company's Franklin, Louisiana, production division. He was graduated from Louisiana State University in June, 1948, with a BS degree in petroleum engineering. Following graduation, he joined Magnet Cove Barium Corporation as a mud engineer and remained with this company 1½ years before joining Shell in January, 1950.

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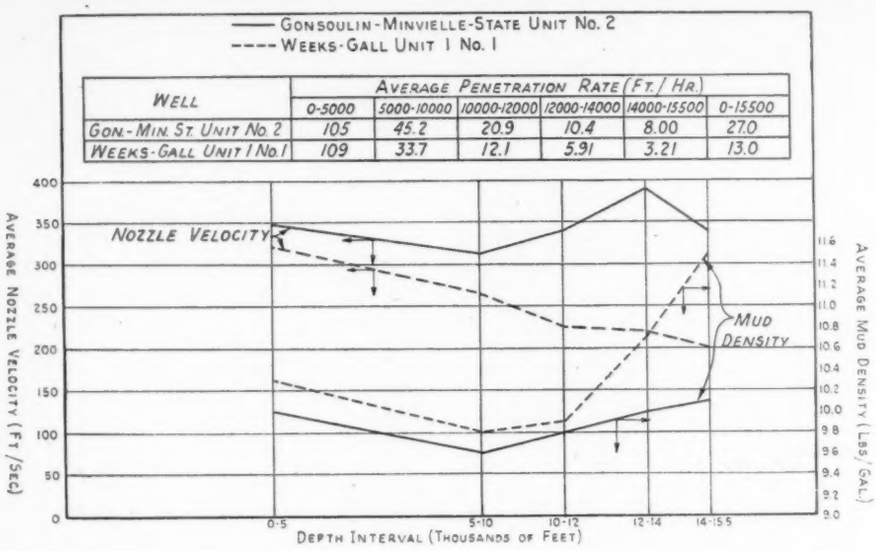
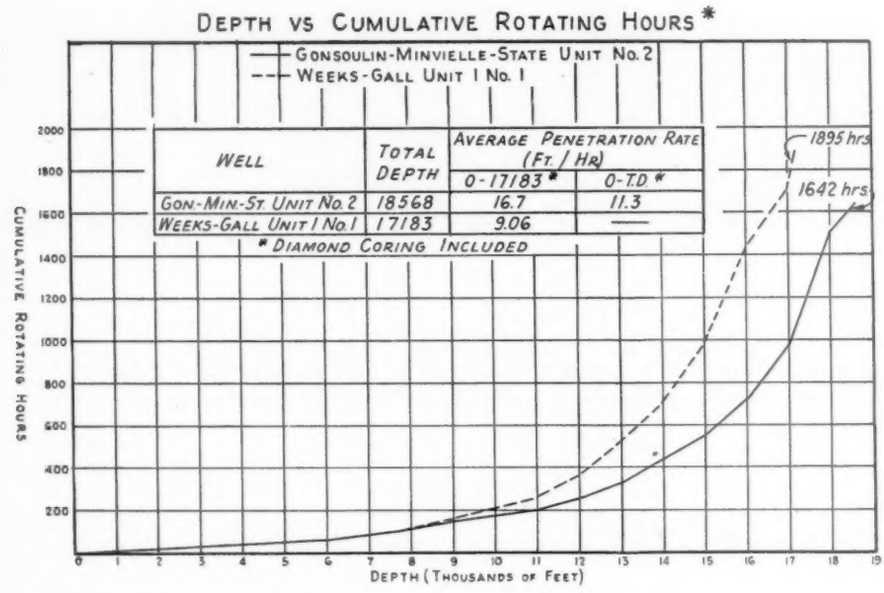


Well	Average Penetration Rate (Ft./Hr.)					
	0-5000	5000-10000	10000-12000	12000-14000	14000-15500	0-15500
Gon.-Min. St. Unit No. 2	105	45.2	20.9	10.4	8.00	27.0
Weeks-Gall Unit 1 No. 1	109	33.7	12.1	5.91	3.21	13.0

FIG. 1. Depth interval vs. average nozzle velocity and average mud density.



Well	Total Depth	Average Penetration Rate (Ft./Hr.)	
		0-17183 *	0-T.D. *
Gon.-Min.-St. Unit No. 2	18568	16.7	11.3
Weeks-Gall Unit 1 No. 1	17183	9.06	—

* Diamond Coring Included

FIG. 2. Depth vs. cumulative hours.

FIG. 3.

Well	Depth interval	Diamond coring: Rotating hours	Diamond coring: Footage	Average penetration rate (ft/hr): Coring	Average penetration rate (ft/hr): Drilling (coring excluded)
GMSU No. 2.....	0-17,175	95	211	2.22	18.1
WGU 1 No. 1.....	0-17,183	266	311	1.17	10.3
GMSU No. 2.....	0-18,568	355	607	1.71	14.0

FIG. 4.

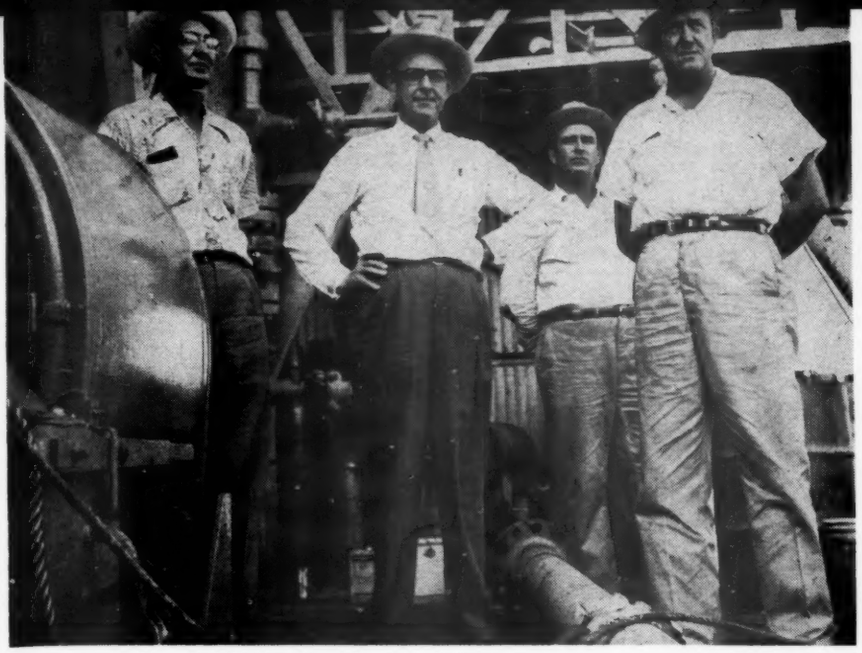
Well	Depth interval	No. of bits (excluding core bits)	Average footage per bit	Average rotating hours/bit
GMSU No. 2.....	0-15,491	48	322	13.1
WGU 1 No. 1.....	0-15,520	70	222	17.0
GMSU No. 2.....	0-17,175	71	239	13.2
WGU 1 No. 1.....	0-17,183	102	165	16.0
GMSU No. 2.....	0-18,568	97	185	13.3

lower solids content mud. A comparison of nozzle velocities, mud densities and penetration rates for the two wells is given in Fig. 1. The depth interval 0 to 15,500 ft was chosen for this comparison because no coring was done in either well in this interval. It can be seen that the average nozzle velocity was consistently higher, and the average mud density was consistently lower in Gonsoulin-Minvielle-State Unit No. 2 than in Weeks-Gall Unit 1 No. 1. With the exception of the interval of 0 to 5000 ft, each interval was drilled much faster in Gonsoluin-Minvielle-State Unit No. 2 than in Weeks-Gall Unit 1 No. 1, with the average rate of peneration in the Gonsoulin well being more than twice that in the Gall well down to 15,500 ft.

In Fig. 2, depth is plotted versus cumulative rotating hours for each well. It took 1895 rotating hours for Weeks-Gall Unit 1 No. 1 to reach 17,183 ft, whereas Gonsoulin-Minvielle-State Unit No. 2 reached this depth in 1031 rotating hours. This reduction in rotating hours represents a considerable saving in rig time alone. Only 1642 rotating hours were required for Gonsoulin-Minvielle-State Unit No. 2 to reach a total depth of 18,568 ft. Fig. 3 gives coring data for both wells. In Gonsoulin-Minvielle-State Unit No. 2, 355 rotating hours were spent in coring 607 ft. This leaves a total of 1287 rotating hours spent in drilling 17,961 ft of hole at an average rate of penetration of 14.0 ft per hour. In Weeks-Gall Unit 1 No. 1, 266 rotating hours were required to core 311 ft, leaving a total of 1629 rotating hours expended in drilling 16,872 ft of hole at an average drilling rate of 10.3 ft per hour. With coring excluded in the interval 0 to 17,183 ft, the Gonsoulin well averaged 18.1 ft per hour as compared to 10.3 ft per hour in the Weeks-Gall well.

A comparison of bit records for the two wells is given in Fig. 4. It is interesting to note that the average footage per bit was considerably greater in the Gonsoulin well than in the Gall well, even though the average rotating hours per bit was several hours less. The 31 fewer bits plus the 31 fewer trips required for the Gonsoulin well to reach the total depth of the Gall well aided considerably in reducing costs.

In Fig. 5, mud types and properties at various depths are given for Gonsoulin-Minvielle-State Unit No. 2 and Weeks-Gall Unit 1 No. 1. The Gonsoulin well was drilled to total depth with red mud and no serious mud problems were experienced. Between 18,000 ft and total depth small increases in the chloride content of the mud were observed after each trip. Apparently, a small amount of salt water was "swabbed" into the hole each time the drill

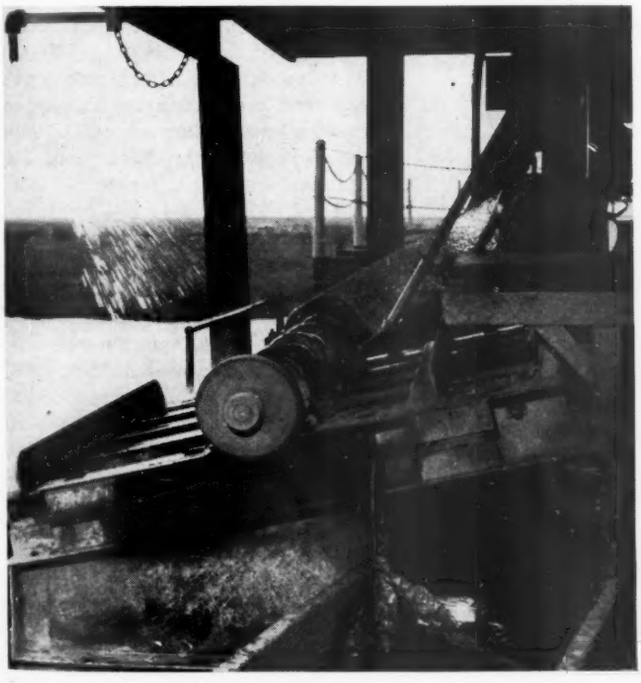


On hand when the Gonsoulin-Minvielle-State Unit No. 2 was completed were: F. P. McIntyre, Sr., Franklin division drilling foreman for Shell; R. N. Myers, area drilling superintendent for the company; Minvielle, who owns part of the unit on which well was drilled; and H. A. Waldrep, drilling foreman of Shell's Rig No. 7.

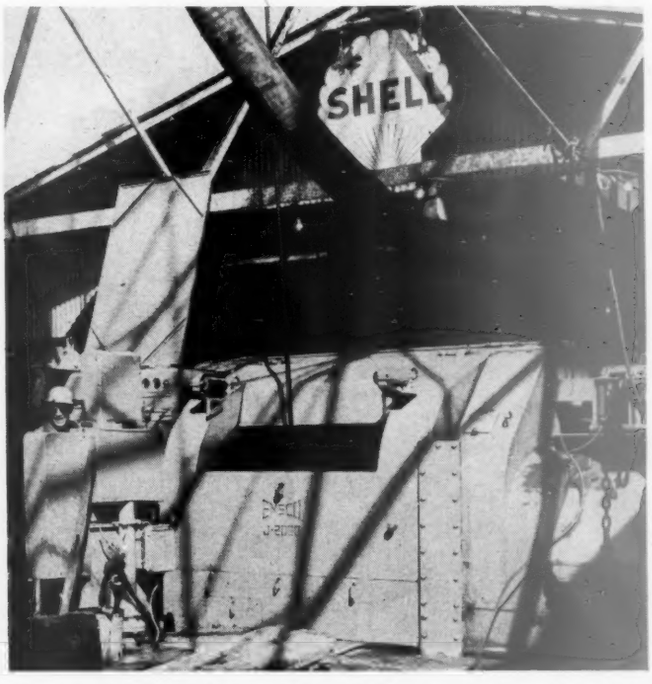
pipe was withdrawn. Even though the mud density was increased from 11.5 lb per gallon to 14.0 lb per gallon, the chloride content continued to increase slightly after each trip. The well, however, reached total depth before the chloride content built up enough to cause serious trouble. The mud was emulsified with oil at 16,100 ft to im-

FIG. 5.

Well	Depth	Mud type	Density (lb/gal)	Funnel viscosity (secs, API)	Water loss (cc's, API)	Chloride content (ppm)	Remarks
GMSU No. 2.....	5,000	Native	9.7	40	—	—	
WGU No. 1.....	5,000	Native	10.1	37	—	—	
GMSU No. 2.....	10,000	Red	9.6	38	20.0	1600	
WGU No. 1.....	10,000	Red	9.9	42	21.0	1700	
GMSU No. 2.....	12,000	Red	9.8	40	16.1	1200	
WGU No. 1.....	12,000	Red	10.2	45	12.7	1400	
GMSU No. 2.....	13,000	Red	10.0	44	11.6	1100	
WGU No. 1.....	13,000	Red	10.5	43	6.8	1600	
GMSU No. 2.....	14,000	Red	10.0	43	10.2	900	
WGU No. 1.....	14,000	Red	11.0	54	6.2	1300	
GMSU No. 2.....	15,000	Red	10.2	57	10.2	1600	
WGU No. 1.....	15,000	Lime	11.7	49	6.4	1300	Converted to lime mud at 14,100.
GMSU No. 2.....	16,000	Red	10.3	44	9.6	1800	
WGU No. 1.....	16,000	Lime-Oil Emulsion	11.6	52	4.6	1500	Emulsified with oil at 15,100.
GMSU No. 2.....	17,183	Red-Oil Emulsion	11.5	52	4.0	1800	Emulsified with oil at 16,100.
WGU No. 1.....	17,183	Lime-Oil Emulsion	13.1	63	3.4	1800	
GMSU No. 2.....	18,000	Red-Oil Emulsion	11.5	58	4.4	2400	
GMSU No. 2.....	18,568	Red-Oil Emulsion	14.0	53	6.2	6200	

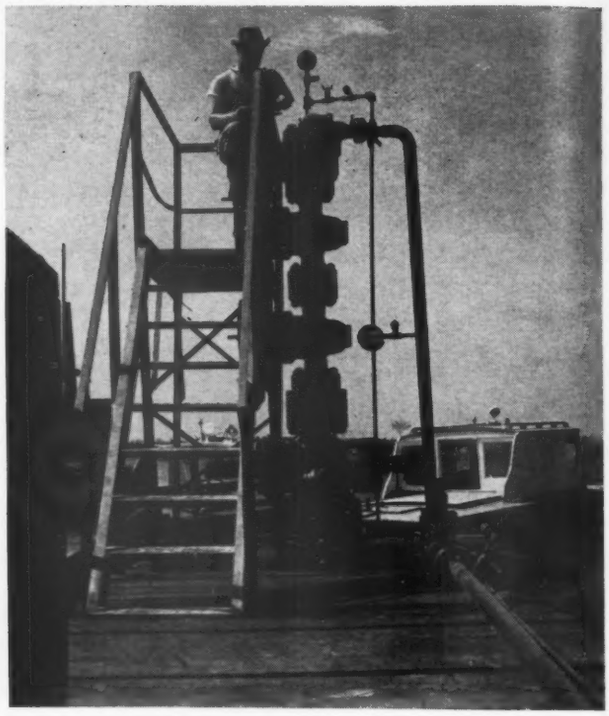


Rhumba shale shaker on Shell Oil Company's Rig No. 7.



Drawworks of Shell rig, which drilled current deepest producer.

Workman connects steam lines on Rig No. 7 boiler barge.



Completed Gonsoulin-Minvielle-State Unit No. 2.

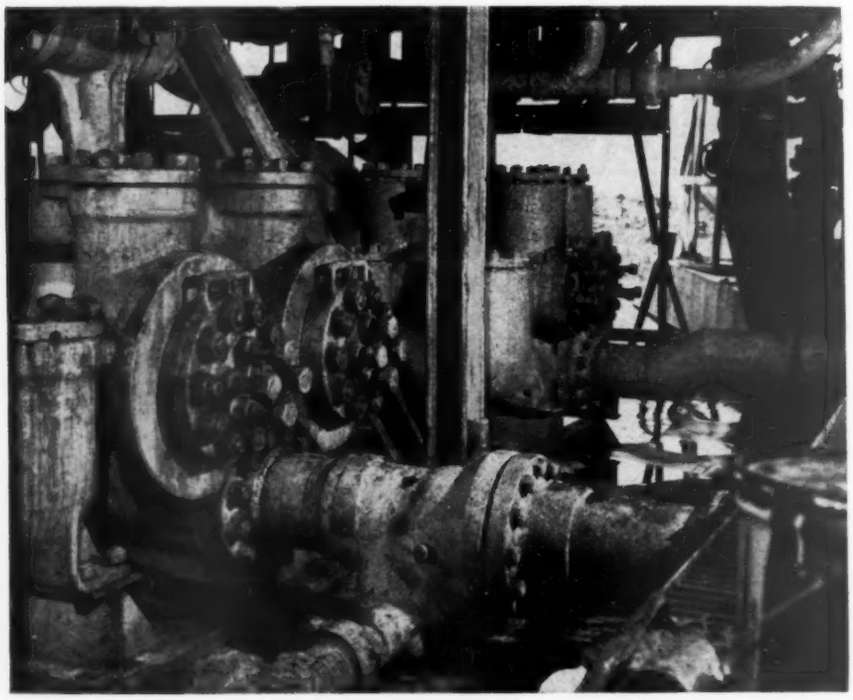
prove hole conditions and reduce drill pipe torque. CMC was used to control the water loss.

Lime mud was utilized in Weeks-Gall Unit 1 No. 1 below 14,100 ft. The well reached total depth without experiencing major mud problems; however, while a final electrical log was run, the mud in the lower part of the hole became semi-solid due to the high formation temperature. The entire system of lime mud was discarded and replaced with red mud to preclude the possibility of the tubing becoming mud stuck during production tests and after completion.

Casing Program

The casing program in Gonsoulin-Minvielle-State Unit No. 2 was as follows: 20-in. conductor at 120 ft (26-in. hole); 13-⅜-in. surface casing at 3027 ft (17-½-in. hole); 9-⅝-in. protective casing at 14,011 ft (12-¼-in. hole) 7-in. protective and production liner at 17,351 ft (8-⅜-in. hole). A 6-in. hole was drilled from the base of the 7-in. liner to total depth. After the well reached total depth, it was discovered that the 9-⅝-in. casing had a hole in it at 3100 ft. As a safety precaution, a full string of 7-in. casing was run inside the 9-⅝-in. casing and cemented at 13,911 ft. No difficulties were experienced in running or cementing any of the casing strings. The 14,011-ft string of 9-⅝-in. casing is probably the longest string of this size casing that has ever been set. This string had a weight in air of 673,000 lb, and a bouyant weight in the hole of approximately 570,000 lb. The last 3000 ft of the string was floated in to avoid excessive loading of the drilling line and hoisting equipment.

The 7-in. liner was perforated for production from 17,260 to 17,268, 17,274 to 17,284, and 17,294 to 17,306 ft with eight jet shots per foot. A combination string of 2-⅞-in. and 2-⅜-in. tubing was set on a retrievable packer at 17,219 ft. The tubing was tested to 9000 psi as it was being run into the well. The density of the red-oil-emulsion mud used in drilling the well was reduced to 11.7 lb per gallon before leaving it in the casing-tubing annulus. After the initial production test was completed, the two bottom hole regulators were installed in the tubing to reduce the flowing tubing pressure. On the official state potential test the well flowed through a 24/64-in. choke at a daily rate of 4,847,000 cu ft of gas and 179 bbl of condensate with a flowing tubing pressure of 3500 psi. * * *



Partial view of the mud pumps on Shell's Rig No. 7; two 22-in. Ideal mud pumps are used for circulation and a 20-in. Ideal is used to mix mud.

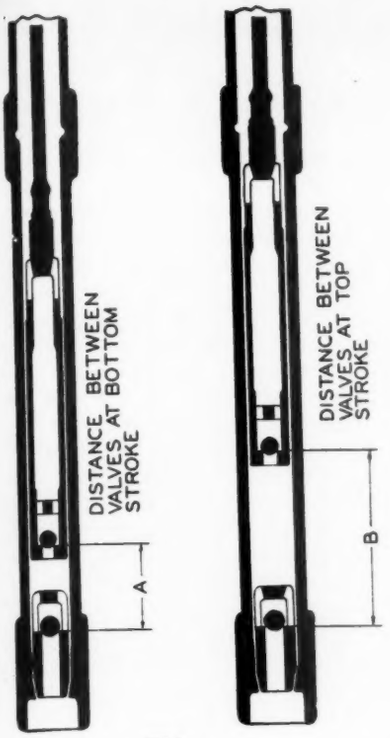


FIG. 1

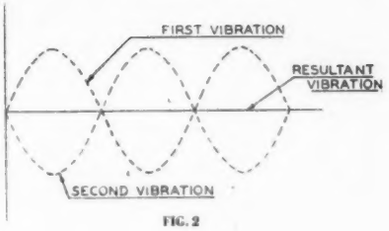


FIG. 2

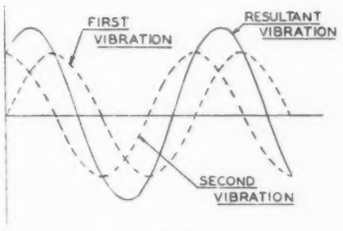


FIG. 3

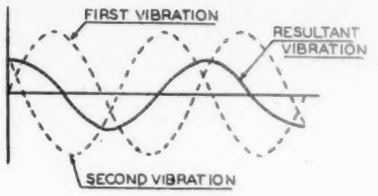


FIG. 4

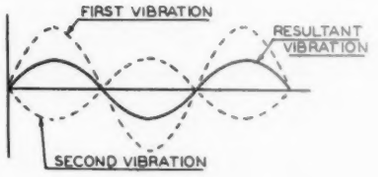


FIG. 5

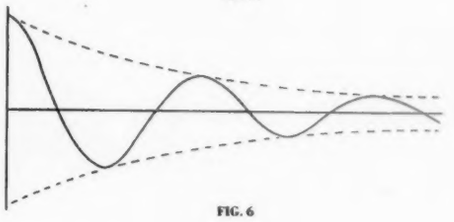


FIG. 6

FIG. 1. Diagrammatic illustration of effective plunger travel.

FIG. 2. Illustration of static system with complementary vibration 180 deg out of phase.

FIG. 3. Illustration of system with compounding vibrations in phase producing a resultant of much greater amplitude.

FIG. 4. System with compounding vibrations slightly out of phase producing a resultant of less amplitude.

FIG. 5. System with vibrations 180 deg out of phase producing a resultant of lesser amplitude.

FIG. 6. System subjected to viscous dampening.

ESTIMATING PUMP PLUNGER TRAVEL

Pump efficiency may be improved and lifting cost lowered by proper speed operation of pumping unit

KENNETH N. MILLS

THE relationship between lengths of the surface stroke and effective length of plunger stroke found in the sucker rod actuated pumping system has been subjected to numerous theoretical analysis. Dynagraph studies of this relationship indicate that all of these approaches fail to yield dependable results. Early attempts to evaluate plunger travel considered the effects of rod and tubing stretch and the inertia of the sucker rod string on pump displacements. A later analysis[1] recognized the existance of longitudinal vibrations in the sucker rod string and attempted to evaluate the effect of these vibrations on plunger travel. This analysis failed to yield acceptable results, because it was assumed that the force inducing the vibrations was the change in direction of motion at the surface, and it failed to consider the effect of tubing vibration. In an investigation of sucker rod vibrations by Mills and Corry[2] it was shown that vibrations are induced into the rod string by the action of the pump valves. As the tubing string is elastic and is subjected to the same forces which induce vibrations into the sucker rods, it must be assumed that it vibrates and, therefore, will affect pump displacement.

To make accurate estimates of effective plunger travel all factors affecting the relative motion between the lower ends of the tubing and rods must be considered. As the rods and tubing are elastic and are subjected to periodically applied forces, rod and tubing stretch must be considered. The surface motion subjects the rods to inertia forces that will induce dynamic stretch commonly called overtravel. Longitudinal vibrations in the rod and tubing strings will influence the relative motion between the lower ends of the rods and tubings and, therefore, effective plunger travel, which is the B minus A as defined in Fig. 1.

To understand effects of vibrations on effective plunger stroke, one must be familiar with the nature of the vibra-

EXCLUSIVE

tory system in an oil well, action of the pump, and basic principles of mechanical vibrations. The oil well contains two vibratory systems that influence pump action. These systems are the tubing and rod strings, and they can be analyzed as steel rods fixed at one end, and subjected to suddenly applied force at their free ends. The action of the fluid column is that of a shock absorber, and it tends to damp out the vibrations existing in the system. The general equation for a vibratory system of this type is shown in most text books on vibration, and it is

$$f = \frac{N}{4L}\sqrt{\frac{E}{d}} = \frac{NV}{4L}$$

where:

f = Frequency, cycles per second
N = 1, 2, 3, ———
L = Length of rod, feet
d = Density, mass per unit volume
E = Modulus of elasticity of material in rod
V = Velocity of sound in material $= \sqrt{\frac{E}{d}}$ feet per second

This equation indicates that the system has an infinite number of natural frequencies, any of which might become resonant with the pumping motion. As the damping forces existing in oil wells are rather large and the higher natural frequencies are quite removed from the highest practical forced frequency, only the lowest frequency of the rod string need be considered. Then the equation for the natural frequency of the system becomes

$$f = \frac{V}{4L}$$

Assuming the velocity of sound in the rod and tubing material to be 15,800 ft per second, equation for the natural frequency of the system is:

$$f = \frac{3950}{L} \text{ cycles per second}$$

$$f = \frac{237{,}000}{L} \text{ cycles per minute}$$

As the forces inducing vibrations are repeated several times per minute, two or more trains of vibration may exist at one time, and the manner in which they combine must be considered. If the system is vibrating at a constant amplitude, and a second vibration of equal amplitude and frequency is induced into the system 180 deg out of phase with the original vibration, the second vibration will cancel the first, and the system will be static. This is illustrated diagramatically in Fig. 2. It is apparent that when these vibrations are added they cancel and place the system in a static condition.

The Author

Kenneth N. Mills received a BS degree in mechanical engineering from Rice Institute in 1933. After he graduated he joined American Manufacturing Company of Texas and became chief engineer of that company. In 1940 he joined Bethlehem Supply Company as chief engineer. During the war he became works manager for Texasteel Manufacturing Company and later assistant chief mechanical engineer of Emsco Derrick and Equipment Company of Houston. He joined Ideco as machinery products manager at Columbus in 1949. His present position is chief engineer with Walter O'Bannon Company, Tulsa, Oklahoma.

The extreme opposite of the foregoing condition would be a system vibrating at a constant amplitude into which a vibration of equal frequency and amplitude was induced exactly in phase with the original vibration. The result of this condition would be a vibration with twice the amplitude of the original vibration as the two vibrations would add directly.

In between these extreme conditions lies an infinite number of possible manners in which two vibrations of equal frequency can combine. Two vibrations of equal amplitude and frequency that are nearly in phase can combine to produce a vibration with much greater amplitude, as shown in Fig. 3. If they are farther out of phase, they will combine to produce a vibration with less amplitude, as shown in Fig. 4.

In each of the foregoing examples the vibrations have been assumed to have equal amplitudes. If the amplitudes are not equal, the results will not follow all of the above rules. In the event two vibrations with unequal amplitude and equal frequencies are combined 180 deg out of phase, the resultant vibration will have a reduced amplitude as shown in Fig. 5. In the event vibrations are in resonance, the amplitude will be equal to the sum of the amplitudes of the two vibrations.

In all of the foregoing examples damping has been neglected. In practice damping always exists. If the system is subjected to viscous damping the amplitude of the vibration will decrease with time, as shown in Fig. 6. The principal damping forces in the oil well are the fluid load resting on either the traveling or standing valve and friction between the pump plunger and barrel. The magnitude of the plunger friction will depend on construction of the plunger seal. Plungers that do not move freely in the barrel may introduce major damping forces. If the system is subjected to large damping forces, the initial vibration may die out before the second is induced into the system.

Vibrations influencing effective plunger stroke are longitudinal and are the result of sudden application and release of load from the rod and tubing string. These vibrations can be visioned as tensile and compressive force waves. When a suddenly applied load is imposed on a long rod, it induces a tensile wave into the member that travels upward in the member at the speed of sound in the material. When it reaches the fixed end, it is reflected as a tensile wave. This wave travels to the free end of the rod where it is reflected as a compressive wave that will be reflected as a compressive wave at the fixed end. Sudden releases of the load will induce compressive waves which will be reflected in a similar manner.

The intensity of these compressive and tensile waves is dependent on the rate at which the load is applied and removed. The rate of load application and release is controlled by the pumping speed and the nature of the well fluid. Considering a given type of well fluid, the intensity of the vibrations will increase with pumping speed. Free gas in the fluid will decrease their intensity, because it increases the compressibility of the fluid. If free gas is present in the pumps displacement space at the start of the down stroke, it will reduce the rate at which the load is transferred from the rods to the tubing. The magnitude of this reduction is controlled by the volume of free gas, and appreciable quantities of gas may reduce intensity of the impulse below that required to induce vibrations. In this event the tubing and rods will not be subjected to vibrations at the start of the down stroke. In most instances vibrations will be induced at the start of the up stroke. Underfilling of the pumps displacement space resulting in "pounding fluid" will subject the system to severe impulse loads that will create vibrations with rather large amplitudes.

As the vibrations are induced into the system by the action of the pump valves, an analysis of their influence on effective plunger travel must consider the relationship between natural frequency of the system and the frequency of valve action. If it is assumed that the time required to execute the up and down portions of the stroke cycle are equal, the analysis can be based on the ratio of the natural frequency to the pumping speed. This condition is rarely achieved in practice. It is closely approached, however. As it affords a con-

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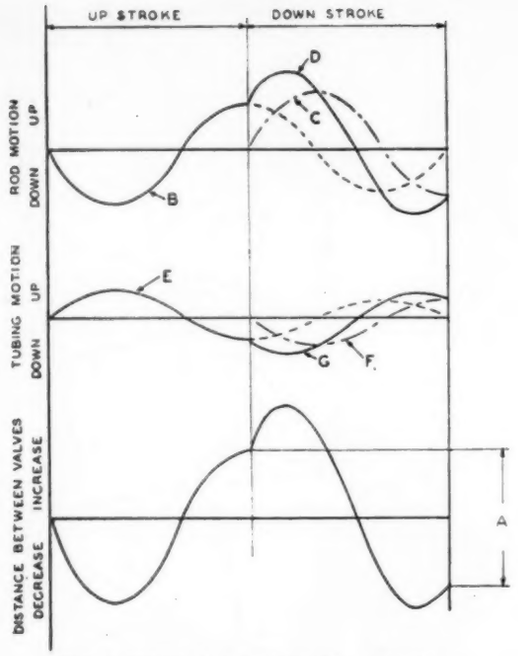


FIG. 7. Effect of rod and tubing vibration.

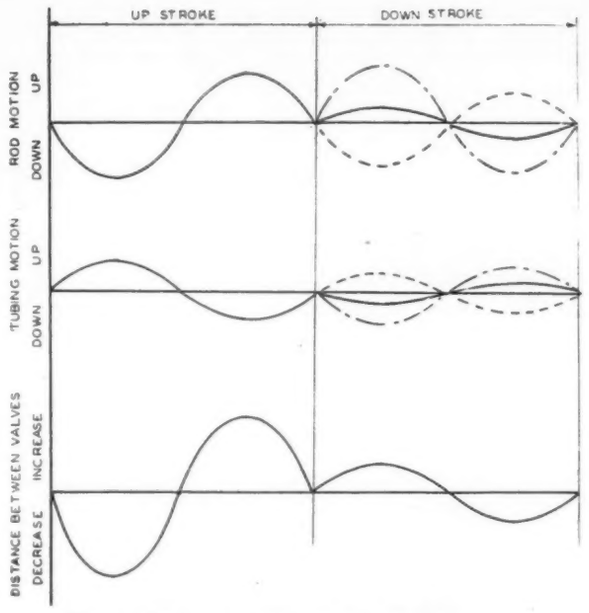


FIG. 8. Effect of rod and tubing vibration.

venient basis for analysis and does not introduce an error of major proportions, it will be used in this study.

The effect of vibrations on the relative directions of motion between the fixed and free ends of the rods and tubing and their effect on the distance between the valves for a frequency ratio of 1½ is shown in Fig. 7. First considering the direction of motion of the lower end of the rod string with reference to the surface motion, the closing of the traveling valve at the start of the up stroke will subject them to an impulse load. This impulse will induce a tensile wave into the rod string that will cause it to move downward and follow the trace B. Opening of the traveling valve at the start of the down stroke will cause a sudden release of the fluid load from the rods. This will induce a compressive wave into the rod string which will cause it to move upward and tend to follow the trace C. This wave will combine with the undamped portion of wave B and the rods will follow wave pattern D.

The direction of motion of the lower end of the tubing with reference to the surface is shown under tubing motion. When the traveling valve closes the standing valve opens. This sudden removal of load from the tubing will induce a compressive wave into the tubing and cause it to move upward and follow trace E. The closing of the standing valve at the start of the down stroke will subject the tubing to an impulse load which will induce a tensile wave into the tubing string, as indicated by trace F. This wave will combine with the undamped portion of wave E, and the tubing will follow wave pattern G.

The combined effect of the rods and tubing vibrations on the distance between the traveling and standing valves is shown in the lower curve. This is related to pump displacement, because increasing the space between the valves at the start of the down stroke and decreasing this space at the end of the

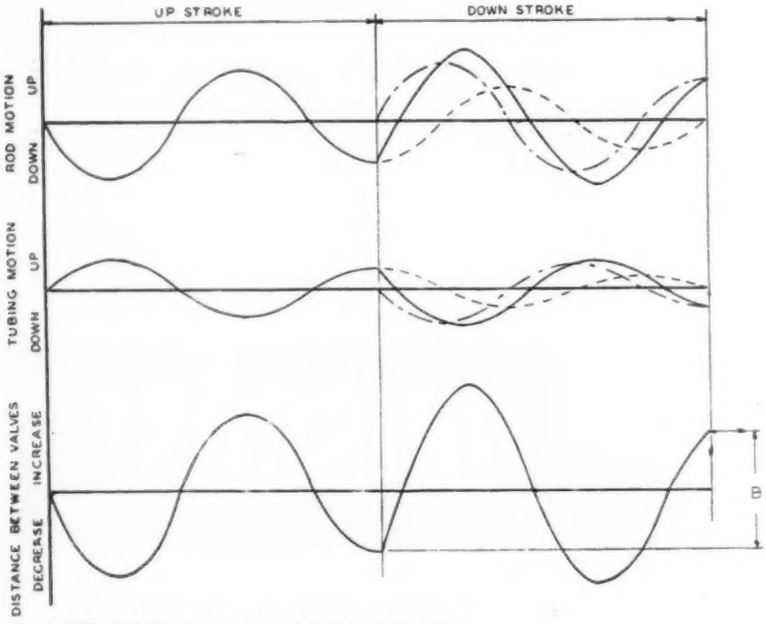


FIG. 9. Effect of rod and tubing vibration.

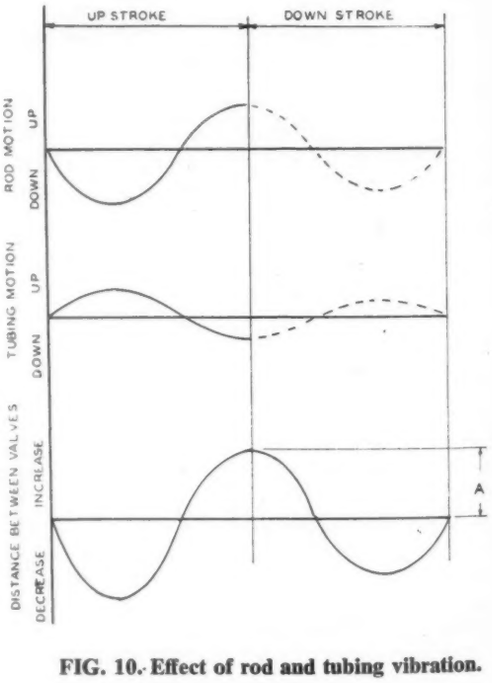
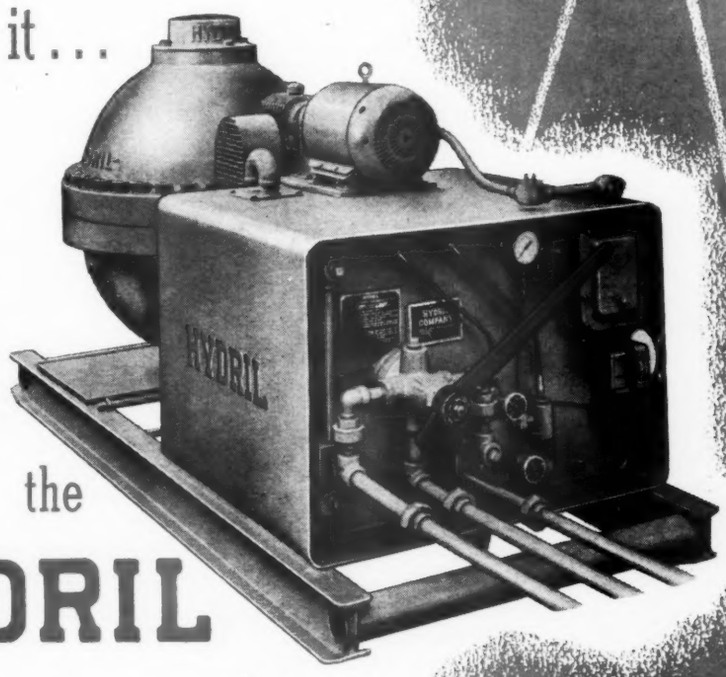


FIG. 10. Effect of rod and tubing vibration.

blowout prevention equipment is no better than the power available to operate it...



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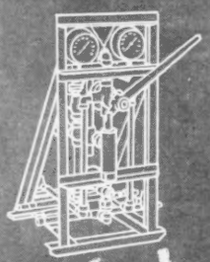

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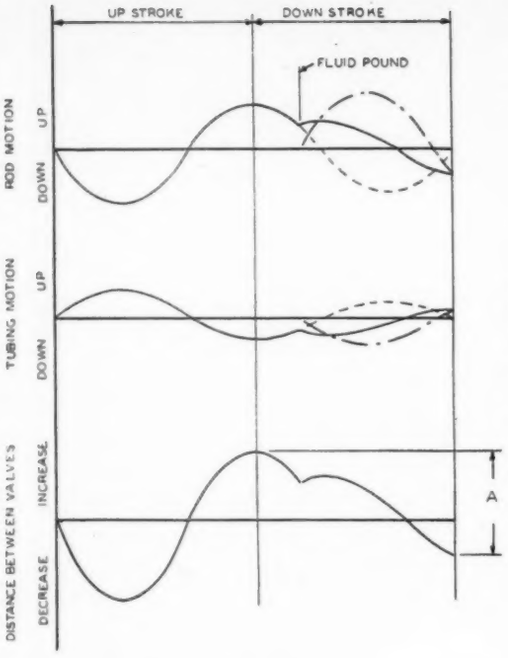

FIG. 11. Effect of rod and tubing vibration.

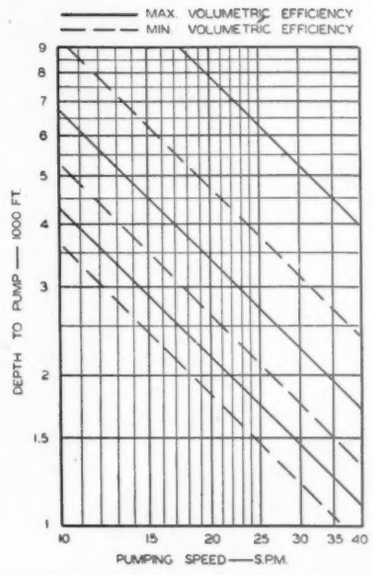

FIG. 12. Relationship between depth to pump and pumping speeds.

down stroke increases pump displacement or effective plunger travel. From this curve it is apparent that rod and tubing vibration has increased the effective plunger travel by the amount A.

The effect of vibrations on the relative directions of motion between the fixed and free ends of the rods and tubing and their effects on effective plunger travel for a frequency ratio of 2 is shown in Fig. 8. It will be noted that when the system is operated under these conditions, vibrations do not influence the distance traveled by the plunger.

Conditions established by operating with a frequency ratio of 2½ are shown in Fig. 9. In this case rod and tubing vibrations combine to decrease the space between the valves at the start of the down stroke and increase this space at the end of the down stroke. Thus the vibrations combine to decrease the effective length of plunger stroke by the amount B.

The probable effect of excessive amounts of free gas in the pumps displacement space when operating with a frequency ratio of 1½ are shown in Fig. 10. In this case, energy is required to compress the gas trapped inside of the pump, resulting in a gradual rather than sudden transfer of the fluid load from the rods to the tubing. Consequently vibrations are not induced into the rod and tubing strings at the start of the down stroke. Under these conditions it will be noted that the effective plunger travel is increased. Magnitude of the increase, however, is less than that experienced when pumping a gas free fluid.

The probable effect of pounding fluid on the effective length of plunger stroke when operating with a frequency ratio of 1½ is shown in Fig. 11. In this case the plunger stroke is increased. It will not, however, result in increased fluid production, because the pump displacement space is not completely filled.

From this analysis it is apparent that the effective length of plunger stroke is a function of the ratio of the natural frequency of the system to the pumping frequency. Also, certain frequency ratios are more favorable to high pump efficiency, because they tend to increase the effective length of plunger stroke. The frequency ratios favorable to high efficiency are 1½, 3½, 5½ etc. The least favorable ratios are 2½, 4½, 6½ etc. The relationship between the favorable and unfavorable pumping speeds and the depth to pump are shown in Fig. 12. As the time intervals between the opening and closing of the valves are rarely exactly equal, each of the lines on this chart must be considered as defining an area within which either maximum or minimum pump efficiency should occur. The exact location of the point of maximum efficiency in a given well will depend on the time interval between valve actions and is controlled by the characteristics of the surface motion, the conditions prevailing at the pump and possibly the condition of the pump.

References

1. Plunger Travel of Oil Well Pumps, R. W. Rieniets, API Drilling and Production Practices, 1937.
2. Effects of Rod Vibration on Dynamometer Cards, Kenneth N. Mills and S. E. Corry, The Oil Weekly, July 24, 1940. ★ ★ ★

Underground Heat Wave Used to Recover Oil

Successful development of a method for recovering the large amount of crude oil now left in the ground by present production means was reported by Sinclair Research Laboratories, Inc. Scientists described a five-year series of field tests which led to a patented Sinclair method for unlocking stubborn oil deposit by means of an underground heat wave produced by a fire in the oil formation itself. Geologists have estimated that as much as 50 per cent of the oil in an average field is too tightly held by the reservoir rock to be recovered by conventional primary and secondary recovery techniques.

The formation subjected in tests to the heat wave treatment was "practically stripped of its original oil content," Bruce F. Grant and Stefan E. Szasz told the annual meeting of the Petroleum Branch, American Institute of Mining and Metallurgical Engineers in New York recently.

Heat wave tests were conducted by Sinclair in a shallow Oklahoma field, the scientists reported, and underground temperatures are estimated to have reached 1000 F.

Although overall recovery efficiency of the process cannot be evaluated until the wave reaches producing wells two years hence, "banking" of the oil ahead of the wave has been shown by exploratory drilling in the area of the tests.

In a summary section, Grant and Szasz's paper presented to the AIME meeting said Sinclair heat wave tests had shown:

1. The feasibility of creating and propagating a combination-supported heat wave throught an oil-bearing reservoir rock.

2. Practically complete depletion of the oil-bearing formation in the heated area, "a result that cannot be approached by any recovery method now in use."

3. Oil present in the formation, with exception of some residual, can be moved by the very front of the wave, before ignition temperatures are reached, and hence should be recoverable.

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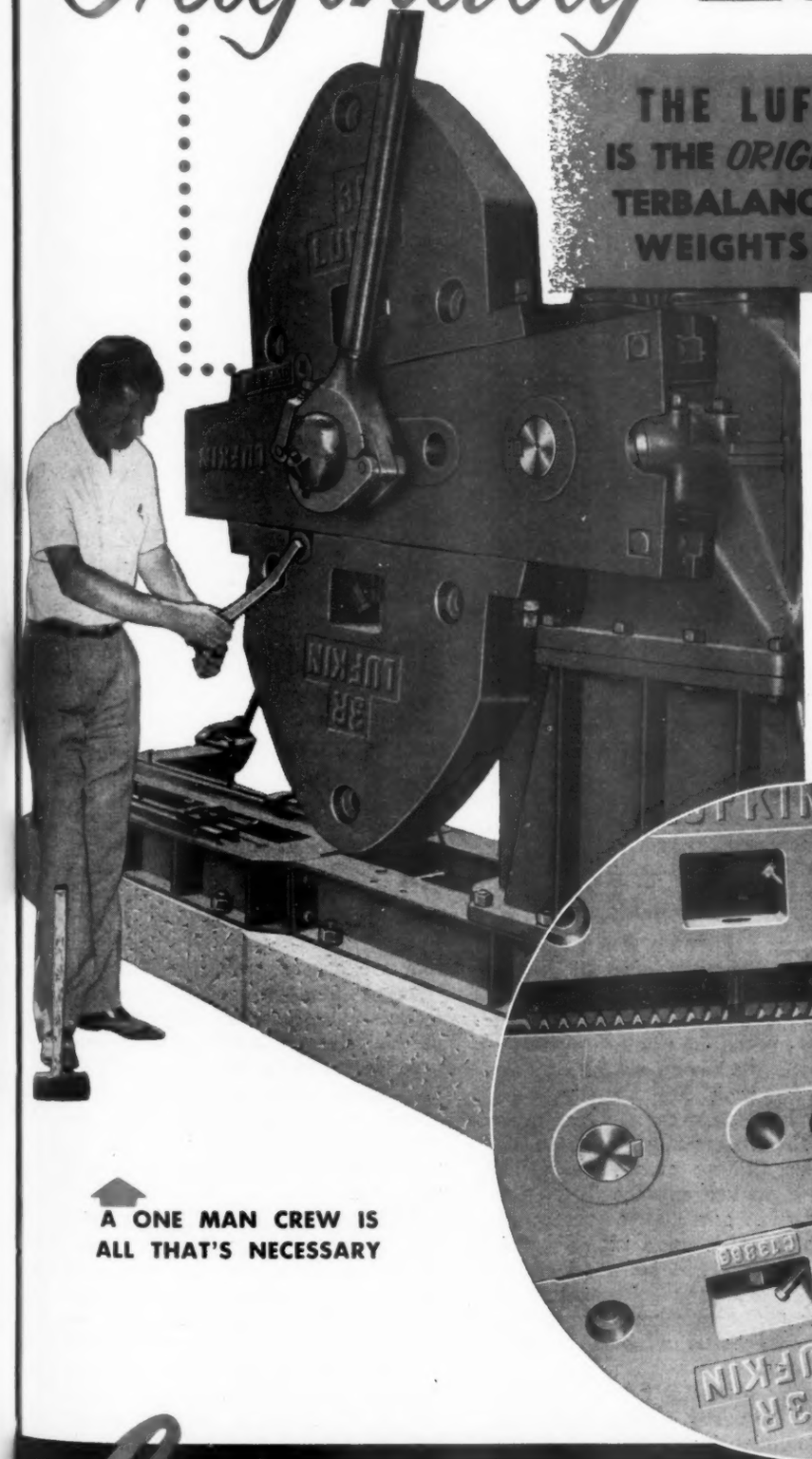

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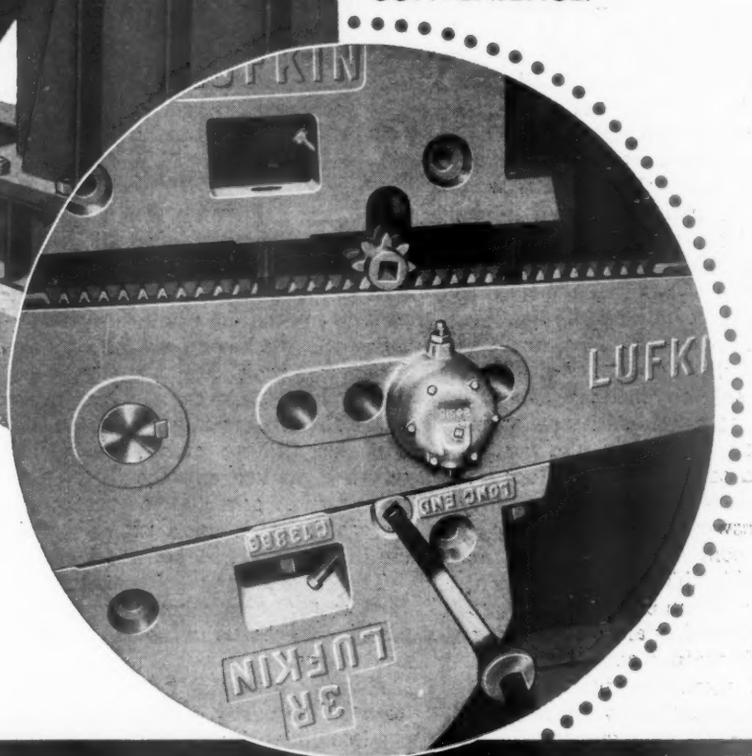

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PERMANENT WELL COMPLETION

Workover cost reductions of 35 to 65 per cent have been experienced in wells completed with this technique. Review of subject should be valuable to operating and engineering personnel

C. V. KIRKPATRICK

Compilation

This paper is a coordinated compilation of the papers presented at the Symposium of Permanent Well Completions held at the University of Houston, January 12, 1954. Contributors to this symposium were: T. A. Huber, T. O. Allen, Gil Tausch, and Jim Dublin, Humble Oil; J. D. Clark, Continental Oil; Harry Schramm, Otis Pressure Control; G. R. Hodgson, Schlumberger Well Surveying Corporation, and C. V. Kirkpatrick, University of Houston.

THE oil operator is continually faced with the problem of the rising cost of producing a barrel of crude oil. During the flush period of the well's life, this cost may be nominal, but as the individual well performance declines and operating problems begin to accrue, the cost curve takes a sharp turn upward with time. In many instances it is significantly high at the beginning of production.

The record shows that the average well depth is steadily on the increase. Deeper drilling means increased cost not only in drilling alone, but also in terms of well completions and well workovers. Management is now asking the question as to why the cost of drilling and completing wells today, is more than it was yesterday—and they want the answer on one sheet of paper.

Development of offshore areas requires considerable initial investment. Operating cost can easily become prohibitive, unless they are carefully considered and carefully controlled.

Lack of significant new field discoveries in recent years means dwindling reserve and consequently a more intensive search for, and development of, crude oil and gas production.

It is fitting, therefore, that a discussion of a new method for completing, recompleting, and reconditioning oil and gas wells be held at this time. Permanent well completions represent an engineering effort to counter some of the more serious implications that have been set out above. This paper will develop the subject matter under the following headings: Basic Objective, Economics, Preparing the Well, Surface Equipment and Accessories, Perforating Operation, Squeeze Cementing and Plugging, Well Conditioning and Treating, Preparation and Testing Prior to Conditioning, Specific Engineering Advantages, and The Future Challenge.

Basic Objective

The basic objective of permanent well completions is to handle a well on a systematized basis, which will result in a reduction of hazards, and a maximum application of known basic principles. This will allow:

1. **A reduction in the cost of producing oil and gas**
2. **Increased reserves**
3. **A more accurate prediction of well behavior**

Economics

The average cost of drilling wells has steadily increased. Simple figures that show only the cost per foot of a well do not tell the whole story. A detailed analysis has shown that in most instances, wells are actually being drilled more efficiently now than in the past. Notwithstanding this fact, the cost for drilling current wells has shown a marked advance in the past few years. A principal reason for this increased cost is more extensive testing in the wells now being drilled.

Therefore, a principal economic advantage to the permanent completion technique is that of *improved*, inexpensive testing.

Another advantage is, that early release of the costly drilling rig is now possible under this method.

Average cost for the conventional land workover has been statistically estimated at approximately $10,000. It is further estimated that 10 of these workovers will be required during the life of the average well. Hence, it can be seen that the conventional workover approaches the original cost of drilling the well.

Cost for initially completing a well by conventional methods will vary from $3000 for the simplest type, that of running pipe and completing in a single zone, to $10,000 for multi-completion tries. It is believed that the permanent well completion technique will reduce these workover and completion costs by as much as 35 to 65 per cent.

For offshore wells the conventional workover costs will run from $100,000 to $200,000 with the average closer to the $200,000 figure. It is estimated that the permanent well completion technique will save 80-90 per cent of this cost.

Preparing the Well

Potentially, the permanent completion technique applies to all categories of wells. Several dually completed wells have already been equipped for wireline workovers. Most Gulf Coast wells that are characterized by multi-zone reservoirs, difficult electric log interpretation, and expensive workovers, are particularly well suited for the permanent well completion technique. The application is currently limited only by certain high pressure wells that have pressures in excess of currently designed through the tubing perforating equipment.

Initially Completed Wells. In order to perform the well conditioning, treating, and squeeze cementing operations that are a part of the permanent completion method, it is necessary to increase the effective length of the well tubing with an extension of small diameter pipe and to provide means for the circulation of fluids from the well head to the bottom of the well bore. Installation and removal of the tubing extension and related equipment is accomplished through the use of conventional wire line equipment. Some of the preparation necessary to

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The Author

C. V. Kirkpatrick is director of the school of petroleum engineering at the University of Houston, where he organized and developed that division in 1947. He was graduated from Texas A & M, receiving his master's degree from the University of Houston. He spent five years in the Army, and two years on rig design with Emsco Derrick and Equipment Company. A consulting engineer in petroleum and natural gas, and registered professional engineer, Kirkpatrick is author of a manual on "Power of Gas," and several technical articles on gas lift and application of fundamental gas laws to gas measurement problems.

establish the desired conditions must be made at the time the tubing is run into the well; others may be made at the time the well is reworked. It is desirable, however, from both the economic and the operational standpoint, to anticipate wire line workovers when wells are equipped initially.

In preparing wells for permanent completion, the tubing must be run open ended to permit the passage of the tubing extension. Means must be provided for both conventional and reverse circulation of fluids from surface to the bottom of the well bore. Provision must be made to lock and seal off the tubing extension within the tubing string.

Equipment required to accomplish these purposes will vary with different types of wells and other well equipment used.

The simplest type of well, one having a string of open-ended tubing suspended within the well casing without a packer, is shown in Fig. 1. An essentially full opening landing nipple is located at the lower end of the tubing.

In a well having a circulation port communicating between tubing and casing above a packer, the effective circulating length of the tubing is equal to the depth of the circulating port. A schematic representation of such a well is shown in Fig. 2. The tubing of this well includes a landing nipple located above a side port nipple.

Other means that may be used in permanently completed wells to provide a circulating port are gas lift mandrels of the off-set type and of the sliding-sleeve type. Use of these gas lift mandrels provides a means of closing the circulating port which will permit passage of the perforating gun through the tubing. A well equipped with an off-set type gas lift mandrel is illustrated in Fig. 3.

Because it may be desirable to close or otherwise control the circulating port, the use of gas lift mandrels or side port nipples is recommended.

The small seating nipple located at the lower end of the tubing is actually needed only in wells having abnormal pressure gradients. It is included, however, as a part of the packer or as part of the production tube by at least two packer manufacturers.

Installation of landing nipples and gas lift mandrels near the lower end of the tubing string does not in any way prevent the use of such full opening nipples and mandrels throughout the tubing string if desired. Ports in gas lift mandrels in the upper portion of the tubing string may be blanked off at will by means of wire line tools.

In the installation of tubing in wells to be permanently completed, attention should be given to the relative location of the various items included as a part of the tubing string.

It is desirable that the nipple or gas lift mandrel that carries the circulation port be located as near the packer as possible. In the case of the off-set type gas lift mandrel, one full joint of tubing should be used between the mandrel and the packer because of the eccentricity of the mandrel.

In many cases, it may be desirable to use a second landing nipple to be located between the packer and the circulating port. This landing nipple provides a seat for a plug or testing tool used to pressure the gas lift mandrel, to load the annulus with mud or inhibitor and to displace such fluids.

In the case of pumping wells, landing nipples are bored to the same internal diameter as API pump seating nipples and may be used as such.

Conventionally Completed Wells. Certain conventionally completed wells can be converted to the permanent completion technique. For maximum advantage the wells should be reworked and equipment installed as indicated for the initially completed wells. This will allow the necessary testing, squeeze-cementing, and other reworking technique as necessary.

Perforating in conventionally completed wells with the tubing gun is commonly done. Removal of tubing plugs provide the principal disadvantage to this operation. This has been successfully accomplished in some instances, although successful removal of the plug is by no means always assured.

The use of the tubing gun in the conventionally completed wells is somewhat hindered by certain wells that have been set with a packer. Excessive tubing weight on the packer results in a corkscrewing effect on the tubing to the extent that the gun perforator may not pass through.

Surface Equipment and Accessories

Perforating. In order to eliminate a derrick or other massive sheave supporting equipment, a small perforating truck using 3/16-in. diameter armored

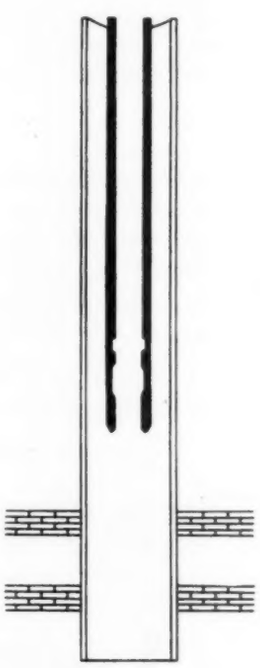

FIG. 1.
SIMPLE WELL

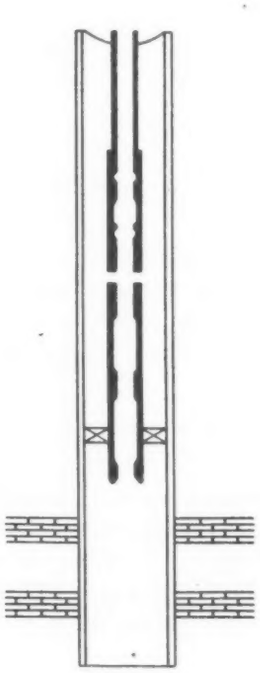

FIG. 2.
WELL WITH PACKER, CIRCULATING PORT AND LANDING NIPPLE

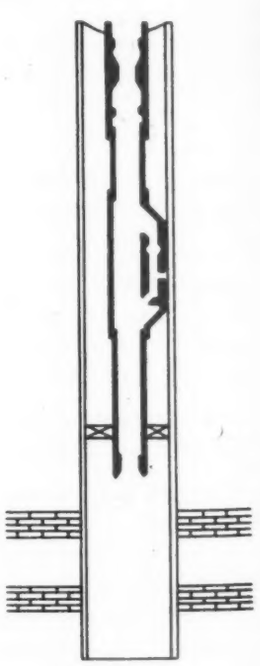

FIG. 3.
WELL WITH OFFSET-TYPE MANDREL

FIGS. 1, 2 and 3. Various types of wells prepared for permanent well completion.

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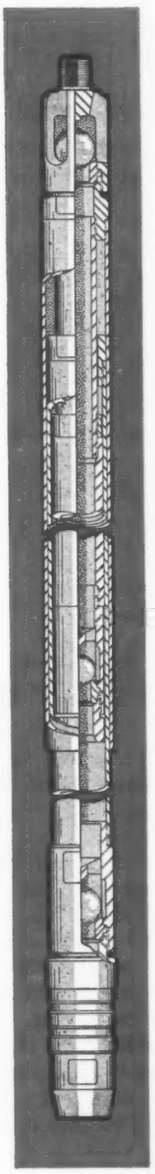

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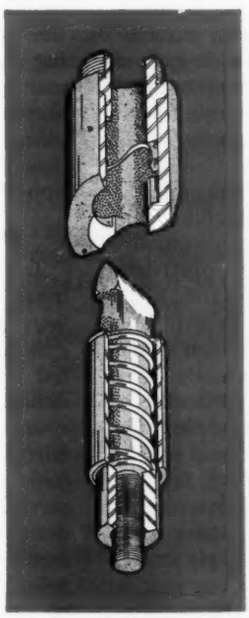

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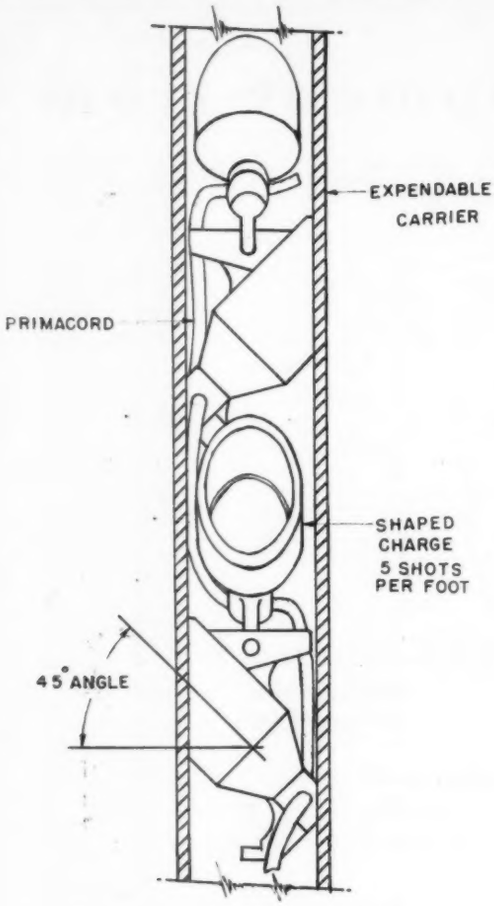


FIG. 4. Expendable shaped-charge gun for permanent well completion.

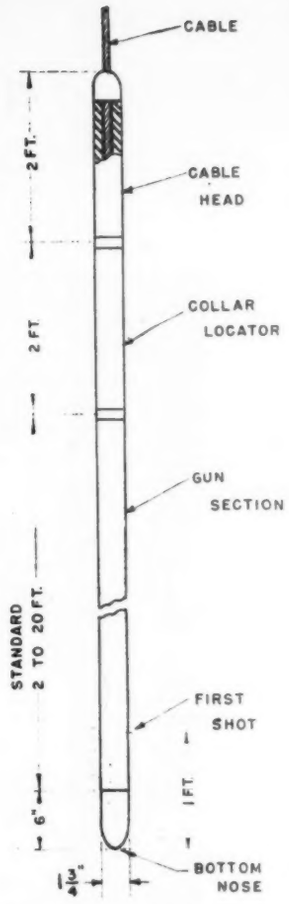


FIG. 5. Assembly of expendable gun as made up for perforating.

cable was designed. This truck has a hydraulic powered winch with a drum capacity for 12,000 ft of cable. In line with other equipment used in this operation, the truck is light and has good maneuverability. The above ground equipment, consisting of blowout preventer, lubricator, stuffing box, sheaves, and gin pole, are carried in this truck. Development work has been directed towards the high pressure above ground equipment that will operate up to 3000 psi. By using this new equipment, higher pressures may be handled after perforating.

Wire-Line Workovers. In the interest of safety and in order to facilitate the handling of the tubing extension, the erection of a personnel platform around the well head is desirable. Such platforms are carried on the wire line truck and are readily assembled at the well site. A gin pole normally used for lifting the wire line lubricator is utilized in removing and inserting the 1-in. aluminum pipe. A cathead is provided on the wire line truck for the handling of long and heavy extensions.

Most wire line workovers have been performed with a .082-in. single strand wire line; however, at least one unit is in operation which utilizes the 3/16-in. stranded line. The heavier unit is intended primarily for use in handling the heavier extensions and is not intended for general use.

As a safety precaution, a blow-out preventer designed to seal around the 1-in. pipe is installed on the well head while tubing extension is being inserted in the well. Under certain conditions, it may be advisable to plug the bore of the extension with a closing tool at its lower end. After the extension is landed, the closing tool may be displaced by pumping into the tubing. If the closing tool is used, the extension should be left open at the upper end.

The Perforating Operation

In the preliminary stages of development, two basic types of perforators were studied, namely the bullet type gun and the shaped charge. The original tests on bullet perforator designs definitely indicated that because of the space limitations (mostly the very short barrel involved) power could not be built into the gun sufficient for the service needed. Various shaped charge designs were attempted and met with mediocre success until an idea was developed whereby sufficient power could be obtained by turning the shaped charge upward at a 45 deg angle. This feature is incorporated in the shaped charges used in the gun today with some modifications and improvements. New designs featuring retractable barrels are now being developed for bullet guns.

Equipment. It was decided that the casing or carrier of the gun would have to be of minimum thickness; therefore, an expendable tubing was selected. The construction of the expendable shaped charge gun is rather simple and can be illustrated in Fig. 4. It will be noted that there are three essential parts to the perforator:

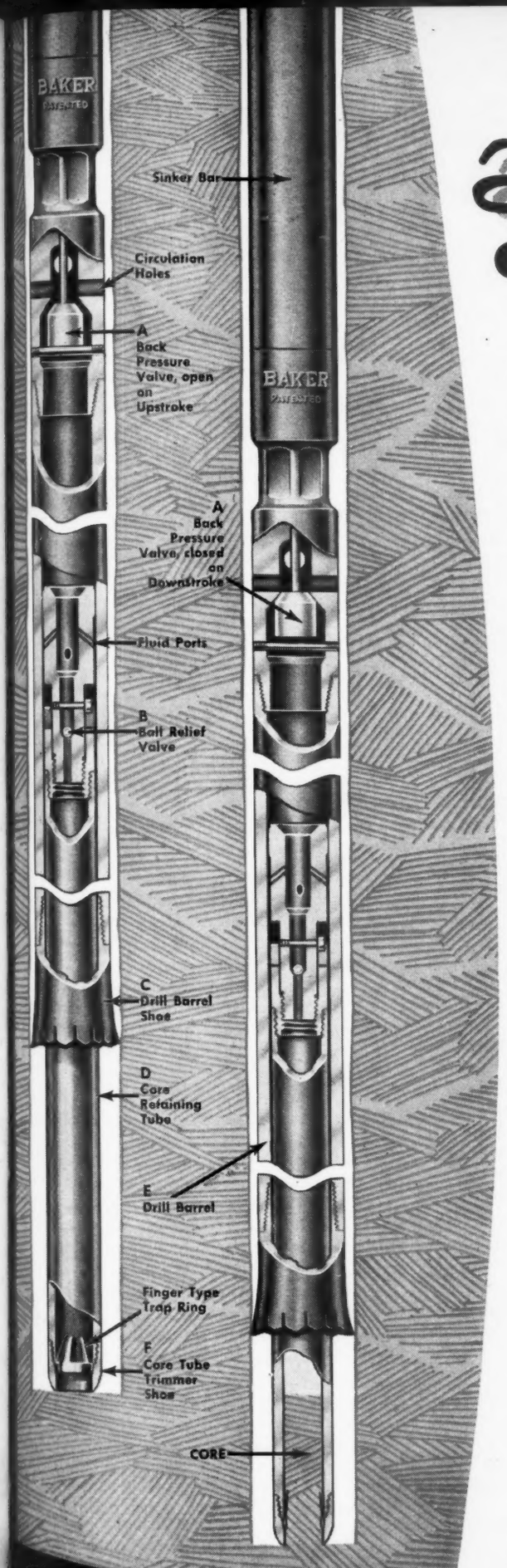
1. **The shaped charges themselves, which are spaced five shots to the foot in a spiral pattern and linked together by appendages fastened to their cases.**
2. **The carrier or body of the gun, which consists of a tube 1¾-in. in diameter and of whatever length is desired for the perforating job for which it is needed.**
3. **The cable head, collar locator, and other apparatus necessary for attaching the gun to the electric cable.**

Functions of these parts, in reverse order, can be described briefly as follows:

1. **The cable head is a mechanical and electrical attachment for the electric line. It and the collar locator, described later, are the only parts that are withdrawn from the well after perforating.**
2. **The function of the carrier or outside case is to withstand the well pressure and to contain the charges until the gun is fired.**
3. **The shaped charges function as hole producing mechanisms and are detonated by means of a primacord running the entire length of the gun. The primacord detonation is generated by means of an electric blasting cap and causes a very swift passage of power up the gun, through the charges, and thus fires them in what amounts to a simultaneous time interval. When the jets are fired, a force stream is generated which pierces the carrier, then the well casing, and on into the formation back of the casing. Shortly after the jet stream has been formed, the carrier itself is destroyed and the pieces drop to the bottom of the well. The cable head and collar locator can then be reeled back to the surface.**

Fig. 5 shows a general assembly of the gun as it is made up in preparation for running into the well.

It will be noted that the outside diameter is 1¾-in., the length of gun can be from 2 to 20 ft, and the collar locator and cable head are approxi-



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The sturdy construction consists of an outer Drill Barrel (E) and an inner Core Retaining Tube (D). The Trimmer Shoe (F) remains in contact with the formation until the core is taken, after which the entire Core Barrel (with core intact) is removed from the well.
The Drill Barrel (E) slides along the Core Retaining Tube (D) and cuts away the formation, thus permitting the Core Retaining Tube to follow down over the undisturbed core and secure a true sample of the formation.

Features which assist in taking good cores include: the Ball Check Valve (B) which permits escape of water entrapped in the Core Retaining Tube so that fluid under pressure never acts on the core; also, the Back Pressure Valve (A) which closes on the downstroke so that water in the annulus between the two Barrels is driven downward with sufficient force to keep the teeth of the Drill Barrel Shoe (C) free from cuttings.

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mately 4 ft in length. This means that on the ordinary perforating job, where no pressure exists prior to running the gun, the lubricator and surface equipment for pressure sealing only has to be of sufficient length to house the cable head and collar locator after the gun is fired.

One of the prime requirements in the perforation operation is that reference points in the tubing and casing be known and recorded. In order to obtain accurate perforating depths and to give the operator a permanent record of the tubing and casing setting, a special magnetic casing collar was designed with an outside diameter of 1¾ in. The locator will show the tubing-collars, casing collars, packer, bottom of the tubing, and bottom of the well. These data can be recorded on a film for future reference. The locator is comprised of two magnetic circuits in opposition with a coil between. Any variation in metallic material adjacent to one of the circuits causes an unbalance in the magnetic circuit, which will produce a transient voltage in the coil, and this voltage change is transmitted to the recorder at the surface. These casing collar logs can then be correlated with other logs obtained from previous services. A sample collar log is shown in Fig. 6.

The actual performance of the gun components are as follows. These shaped charges produce an ellipitical hole in the casing ⅜ by ¼-in. Tests in target composed of ½-in. steel plate equivalent to 9⅝-in. 38 lb casing and 7-day old cement gives a drainage hole 5½-in. long and a horizontal penetration of 3¾-in. Wells have been completed in 7-in. casing and also through a double string of 2-in. tubing and 5½-in. casing. The carrier tube presently used has an external pressure collapse rating of 7000 psi. It is a brittle, aluminum alloy and shatters satisfactorily. Because of its construction, no casing splitting has been noted. Recent experiments have indicated that the carrier fragments can be satisfactorily dissolved by the use of caustic soda placed at the proper position in the well bore.

Technique. As this is sometimes called a tubing gun, the tubing itself must be considered as an important part of the well. It must be full opening from top to bottom and without undue cork screwing because of extra weight on packers or hangers. The use of a gage, the size of the gun to be run, is recommended. The bottom of the tubing should be placed far enough above the zone to be perforated so that tie-in casing collars will be exposed to the locator travel after it leaves the tubing. The well should be washed so that none of the drilling mud remains opposite the zone to be perforated and the amount of water or oil cushion carefully considered.

The casing collar records have been as valuable as was anticipated; and in addition, it has been found that the signal on the recorder while going down serves as a definite indication of the downward motion of the gun.

As one of the main advantages of this method of perforating is that a differential pressure can be obtained into the well bore, it is of a decided advantage to calculate the hydrostatic head against the potential producing zone rather carefully. A differential pressure of 200 or 300 lb should be used, with the anticipated formation pressure being higher than the hydrostatic pressure of the water or oil cushion. Experience has shown that overzealous use of this differential pressure can result in a violent inrush of gas and oil into the well bore immediately after shooting, with possible damage to the reservoir, the cable head, and cable itself. Some method for unloading of the well after perforating should be considered and provided. Productivity results from this method of perforating have definitely proved that the amount of oil obtained is equal to or better than that obtained on wells perforated by conventional methods.

Limitations. Current limitations to the tubing gun perforator are principally those of lack of penetration. This limitation; however, is definitely minor. New gun designs appear to have eliminated this objection.

Another limitation is characterized by the difficulties encountered in high pressure wells such as collapse pressure of the gun carrier, and certain electrical cable difficulties that are experienced under these high pressures.

Depth measurement and line handling particularly in operations that involve the new stranded line unit used in deeper well work are sometimes difficult operations.

Squeeze-Cementing and Plugging

As in many other operations on permanently completed wells, the tubing extension is the basic tool used in squeeze cementing and plugging. This extension has in most cases been assembled from 10-ft joints of a 1-in. aluminum tubing, connected by iron couplings. The extension, assembled to the desired length, is connected to the lower end of a hanger which is designed to lock and seal off in the landing nipple immediately above the circulating port.

With the tubing extension locked in place in a simple well installation such as that shown in Fig. 7, cement may be pumped into the tubing, through the tubing extension and into the well bore

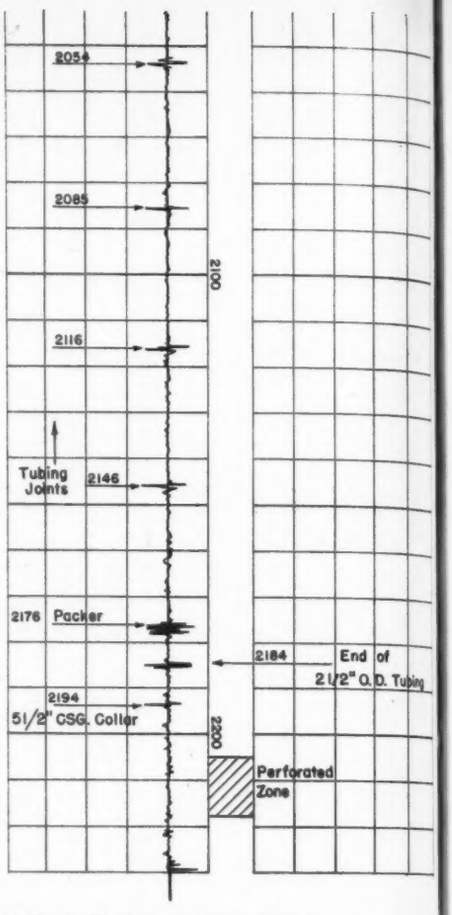

FIG. 6. Typical casing collar log.

below. If a plugging operation is to be performed, sufficient cement should be used to fill the bore to a point slightly above the level at which the plug is to be cut. If perforations are to be squeezed, cement will rise to the level of the uppermost perforation. After squeeze pressure has been maintained for the proper length of time, excess cement is removed from the well by reverse circulation, Fig. 8. Cement returns to the surface through the tubing extension and the tubing.

Although it is possible to perform a high pressure squeeze on wells equipped with packers, the simpler Bradenhead squeeze is to be preferred because high squeeze pressures are not required.

With the extension in place and the extension hanger locked and sealed in the landing nipple, cement may be spotted opposite the perforations. The Bradenhead valve is then closed and squeeze pressure applied through the tubing, Fig. 9. After squeeze pressures are released, excess cement is removed by reverse circulation to a level approximately one foot below the lower extremity of the tubing extension. Such a pattern of circulation is shown in the schematic representations in Fig. 10.

As soon as removal of the excess cement is completed, the extension hanger and extensions are removed

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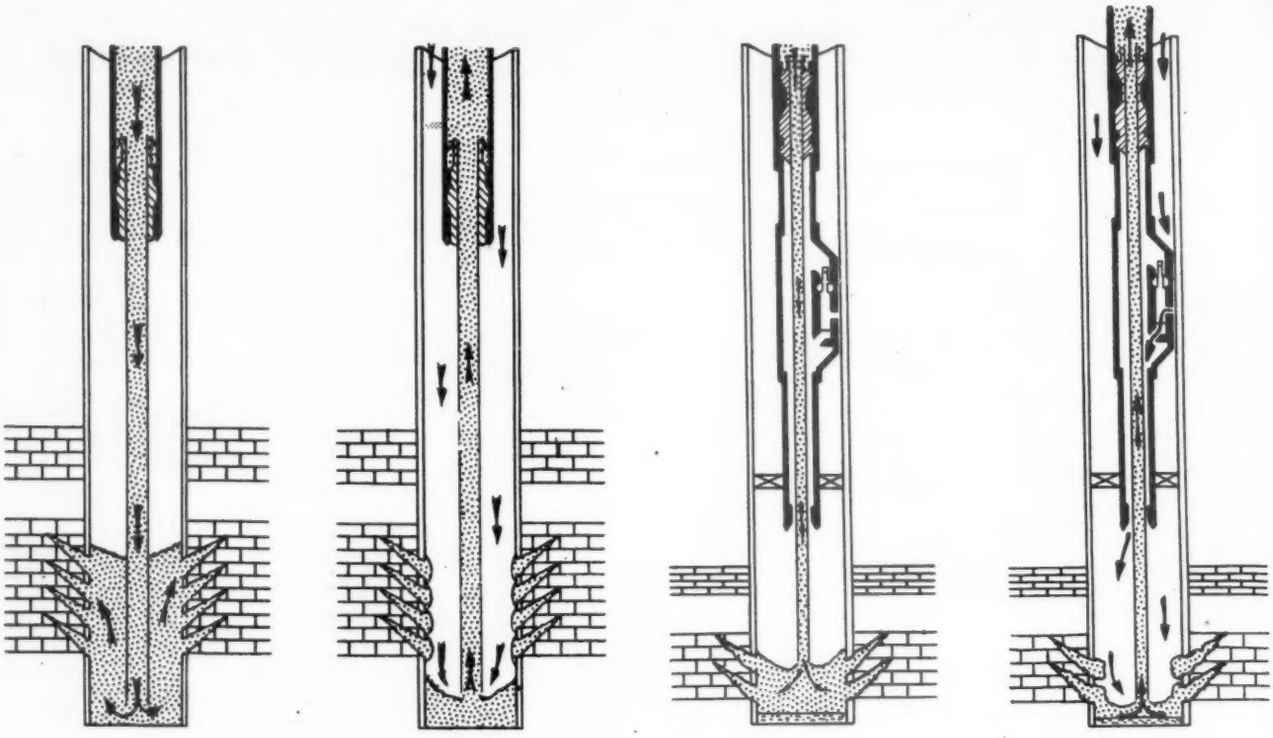


FIG. 7. SQUEEZE CEMENTING

FIG. 8. REMOVING EXCESS CEMENT

FIG. 9. SQUEEZING

FIG. 10. REVERSING

Squeeze cementing operation with various types of permanent completions.

from the tubing by wire line tools, (except in wells having abnormal pressure gradients, in which case the extension is raised to the surface and suspended within the well tubing until after cement has set).

In some cases it has been found desirable to cut the cement plug at a level above that at which the cement is spotted. Such a procedure provides a plug of more uniform density. For this type of operation a tool known as a plug cutter is included in the tubing extension, Fig. 11. This tool consists of two check valves, one which is situated at the lower extremity of the extension. This valve permits flow from the extension to the well bore, but closes when flow is reversed. The second valve is situated at the level at which the plug is to be cut and is of a sleeve type construction. This valve opens only under reverse circulation, causing only that cement above it to be removed. As soon as this cement is removed, the extension hanger including that portion extending into the cement plug is removed.

With few exceptions, the squeeze cementing of wells with abnormal pressure gradients follows the same procedure as that for wells with normal pressure gradients. Such wells are loaded with salt water, and to permit the insertion of the extension into the tubing under atmospheric pressure, an expendable plug which is run on a wire line is seated in the small nipple at the lower end of the packer or tubing.

After the cement has set, wire line tools are used to check the level of the cement in the well bore.

After recompletion, before the well is placed back on production, a tubing stop should be placed in the tubing string, near the lower end, to prevent the accidental passage of tools or instruments into the open flow well bore. This device is installed and removed with wire line tools.

Well Conditioning and Treating

During the course of the well's productive life, it may become necessary to remove sand fill or other material from the well bore or to treat producing formations with acid. As it is contemplated that the tubing installed in permanently completed wells will not be removed during the productive life of the well, provisions must be made for perforating such operations through the tubing.

Sand fills or other material that may accumulate in the bottom of the well bore may be removed by reverse circulation, using the extension equipped with one or more telescoping joints. The schematic diagram shown in Fig. 12, illustrates removal of sand in this manner from a well which is not equipped with a packer. Reverse circulation moves the sand or other matter into the lower end of the extension and upwardly through the extension and tubing to the surface.

Removal of fills from wells which are equipped with packers, Fig. 13, may be accomplished with the same type of extension already described. Circulation, as in the removal of excess cement, is established downwardly through the tubing-casing annulus, through the circulating port into the annulus between well tubing and extension and into the lower end of the extension, returning to the surface tubing.

The telescoping joints serve to maintain continuous contact of the extension with the fill, and the actual rate at which the extension feeds into the fill is influenced by the position of the telescoping joints plus that portion of the extension which is located beneath serve to force the lower end of the extension into the fill.

Once reverse circulation is established and the sand or other material comprising the fill is placed in motion, circulation should be continued without interruption until either all of the fill has been displaced or until sufficient fill has been displaced to allow the telescoping joints to extend to their full length. In no case should circulation be discontinued as long as returns carry any appreciable quantity of sand

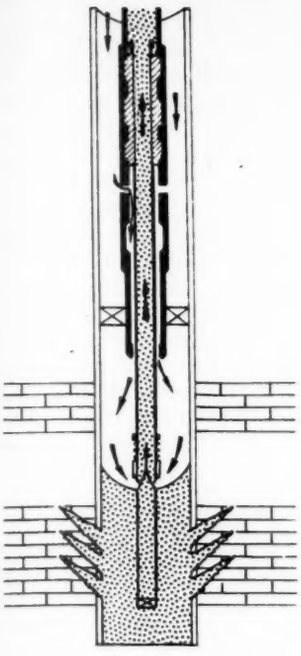


FIG. 11.
CUTTING CEMENT PLUG

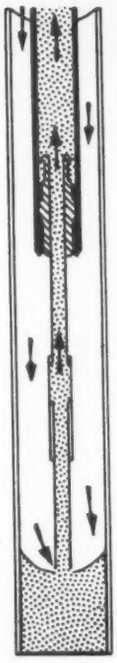


FIG. 12.
SAND REMOVAL

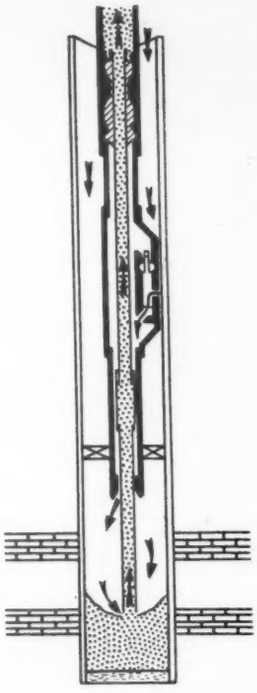


FIG. 13.
SAND REMOVAL

Clean out operations with various types of permanent completions.

or other solid particles, and it is advisable to continue circulation after returns have been found free of solids for a period not less than the time required to displace tubing volume.

Circulating media may be fresh water, salt water or oil, depending upon well conditions.

In some cases, fragments of the perforating gun left in the well bore may interfere with subsequent operations. These aluminum fragments may be dissolved by caustic which is spotted by means of an all-steel tubing extension having a telescoping joint. Using the same equipment, acid may be spotted to dissolve a cement deposit or plug from the well bore. The spent acid or caustic may be removed by reverse circulation.

Acidizing of producing formations in permanently completed wells has in most cases been performed with an all-steel tubing extension. It is estimated that some 24 such operations have been completed to date. At least one acidizing operation has been performed with an aluminum extension. Since the extent of the action of the acid on the aluminum was not known, caustic was used to dissolve the remainder of the extension.

Some of these well conditioning and treating operations can be accomplished with a slip-type extension hanger.

If a tubing stop has been installed in the tubing, it should be removed to allow free passage of wire line tools.

Prior to performing squeeze cementing, fill removal, or acidizing operations, a gage should be run on a wire line to assure that the tubing is fully open and that passage of tools will be unrestricted.

In wells equipped with gas lift mandrels of the off-set type, the gas lift valves should be replaced with "dummy" valves except in the lower mandrel which provides the circulating port. A check valve body, with the checks removed, to permit free circulation in either direction may be placed in the lower mandrel. It is true that the side pocket may be left unfilled for this purpose, but the check valve body serves to divert wire line tools from the side pocket during subsequent operations. If sleeve type gas lift mandrels are used, the upper mandrels may be closed by means of wire line tools and the lower mandrel left in the open position.

In wells not equipped with a packer, the tubing and casing contents may be displaced by salt water, or the desired loading media without any preparation. In wells equipped with packers, with the upper gas lift mandrels closed and the circulating port open, the well may be loaded with salt water to the depth of the circulating port by either reverse or conventional circulation.

A measurement should be made with the wire line to check the position of the landing nipple, the lower end of the tubing and the bottom of the well. These measurements are made with a single tool that locates all the three reference points on a single run of the wire line tools. These measurements are then coordinated with the collar log of the well.

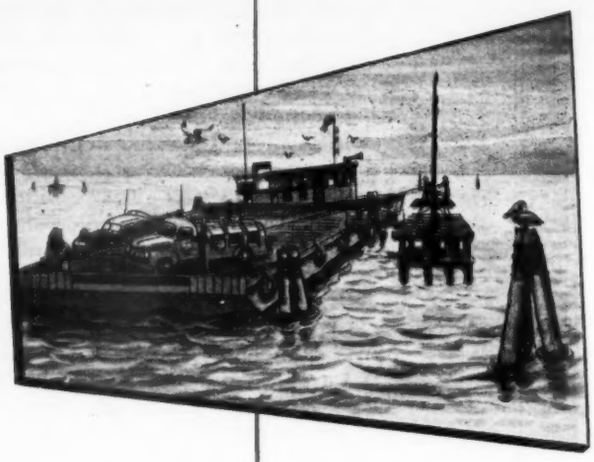
If it is found that the well bore has filled or is otherwise obstructed to a level which may later interfere with perforation of a productive interval, this fill or obstruction should be removed. Testing of the tubing in both burst and collapse may be accomplished after the extension and hanger are in place in the landing nipple. A prong which carries a packing to a seal off within the bore of the extension hanger is attached to the extension hanger running tool and may be pinned in place. With the tubing thus plugged at the depth of the landing nipple, test pressures may be exerted within the tubing or in the tubing-casing annulus, as desired.

After testing is completed, the running tool and prong are released from the hanger by jarring action of the wireline tools, which may be lifted to the surface and removed from the well tubing.

Specific Engineering Advantages

Application of the permanent completion technique has been marked by many engineering problems. As opposed to the conventional method of completing wells, certain practical engineering advantages become immediately apparent. These advantages are aside from those previously listed under the heading of economics. Specific advantages are as follows:

1. A workover rig set-up of approximately ½ ton can now accomplish what formerly required a 2-300 ton rig set-up.
2. Depth presents no particular problem. A 12,000 ft well can be worked over with practically the same requirement as that for a 6000 ft well.
3. Increased reserves are bound to accrue because of the relative inexpensiveness of the testing technique, and because of the improved application, such as perforating in oil and salt water.
4. Improved cementing results and techniques are evident.
5. Individual well behavior can be more easily predicted because of:
   a. *Reduction in the "skin effect" by perforating in a suitable fluid medium, and with a favorable well to formation pressure differential.*
   b. *The application of "through the tubing" fluid flow and water influx instruments will allow assimilation of valuable bottom hole fluid flow data.*
6. The permanent type completion



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will allow drilling in areas that are now economically prohibitive by conventional methods.

7. And finally the permanent well completion technique allows the well to be handled on a systematic basis which permits relatively simple application of basic principles and practices that are known to produce optimum results. It is emphasized here that although many of these basic principles and practices can and have been put into practice by the conventional method, the permanent completion technique has the application inherently "built in" and hence can accomplish the desired results at greatly reduced cost and effort.

The Future Challenge

The future challenge posed by this technique is most formidable. It brings the problem of "slim-hole" drilling into sharp focus. Equipment is already being developed that will clear four-inch casing. All current "through the tubing" equipment and devices are constantly being improved. New developments are being made that will give a complete picture of well and reservoir behavior.

One aspect of the challenge is to put into practice the well known principle that a "slim-hole" with little or no formation damage due to completion practices is better than a large diameter "hole" with considerable formation damage due to conventional completion technique.

The rapidly expanding application of the permanent type method is the indicator as to how well this challenge is being met.

A most encouraging feature of the entire technique is the rapid and thoroughly competent manner in which the equipment manufacturers have developed the required equipment as needed.

The development of the tubing perforating gun, the wire line equipment group, suitable packers, and the artificial lift equipment to single out a few.

Although, remarkable progress has been made, and very encouraging results have been obtained it is well to keep the permanent completion technique in its proper perspective. It obviously does not have an unlimited application at the present time. More important, it certainly does not have an indiscriminate application. Improvements both in equipment and technique are needed in order to broaden the scope of its application. But if the past performance represents any measure of the future, it is reasonable to expect that these improvements will soon be at hand.

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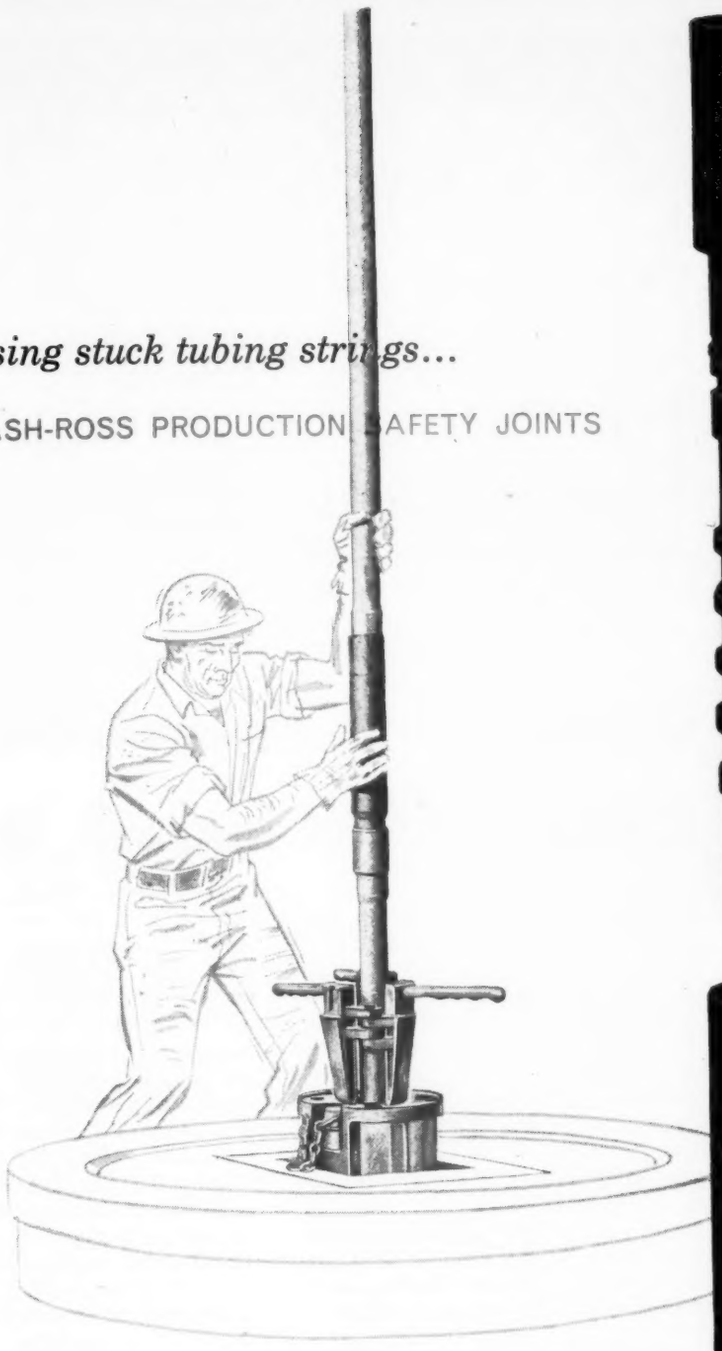

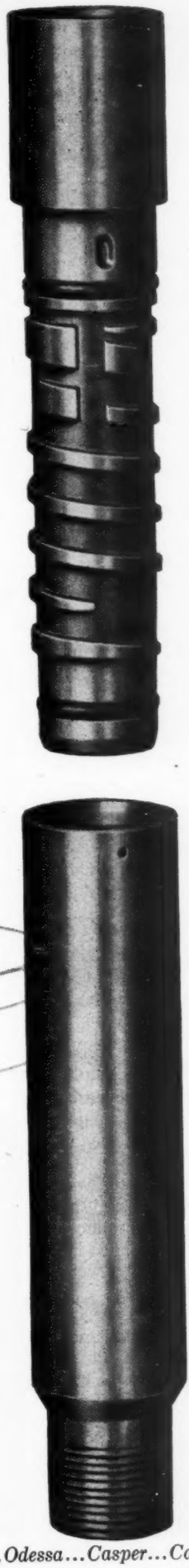

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the concept and development of the permanent type completion technique in the oil industry is comparable to that of the unbelievably small though extremely powerful transistor in the field of electronics. Its full potential has yet to be realized.

Acknowledgement

Acknowledgment is made of the following individuals whose specific contributions have made up this paper:

T. A. Huber, T. O. Allen, Gilbert Tausch, and Jim Dublin of the Humble Oil and Refining Company; J. D. Clark, Continental Oil Company; Harry Schramm, Otis Pressure Control, who contributed the material concerning wire-line operations and well conditioning, and G. R. Hodgson of Schlumberger who contributed the section on perforation.

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Canada Now Among Leading Oil Nations

Canada's western oil boom, which has placed her eighth among the oil-producing nations of the world, really dates back to seven men who, struggling to save Western Ontario's oil production, decided to work together rather than independently.

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Its discovery touched off a new area of exploration, an area so valuable that Canada has her place in the oil nations of the world.

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Going back to the first days of oil in Canada, the major problem was not production . . . but how to get rid of the gasoline that was an inevitable but unusuable by-product of refining kerosine from crude oil.

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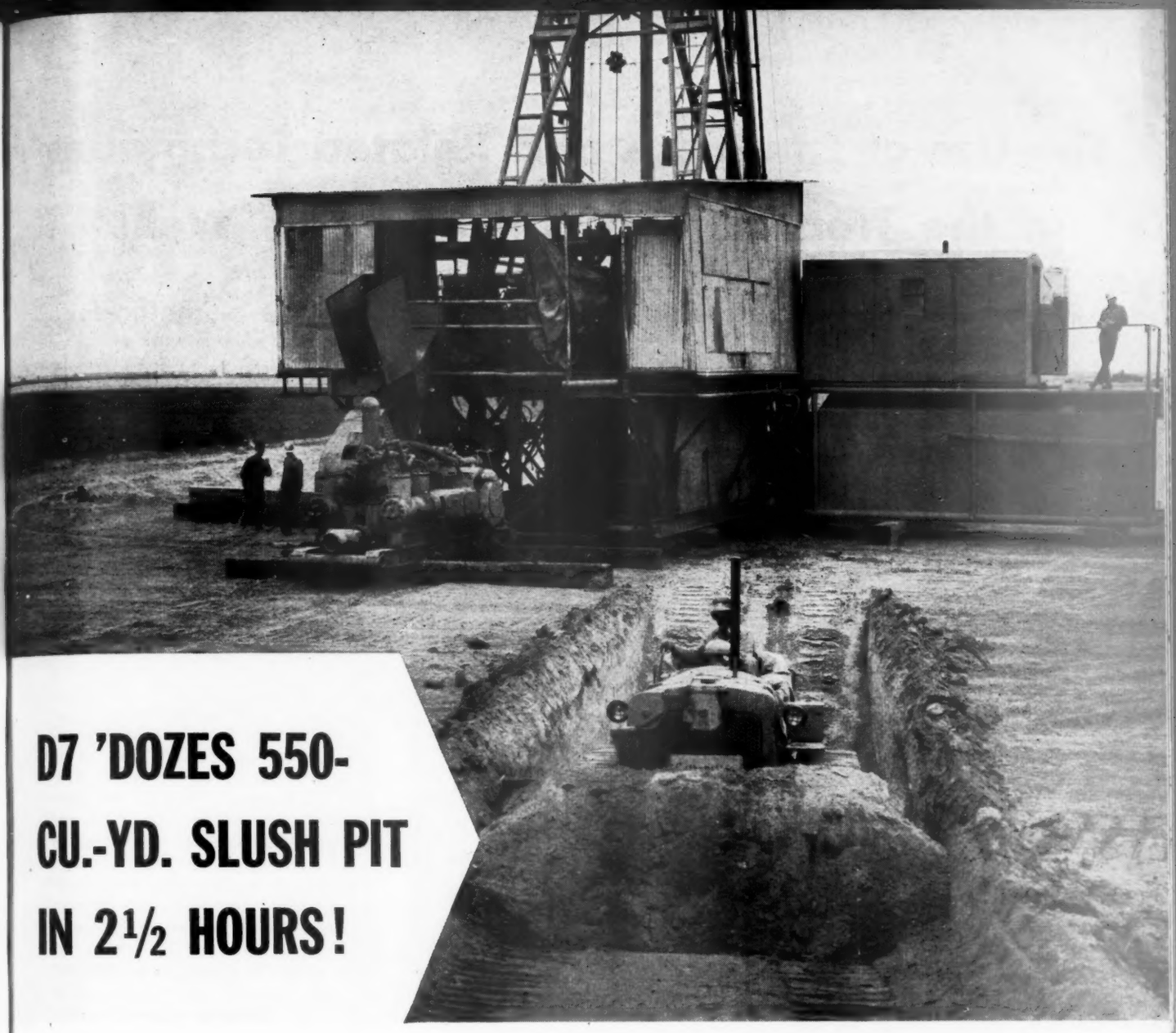
Oil Industry Units, Employees Help Battle $500,000 Fire at Blackwell, Oklahoma

FIRE starting in the rear of an automobile supply and furniture store in Blackwell, Oklahoma, about 7:00 p.m. April 3 raged out of control in a span of minutes. First to supplement the northern Oklahoma city's four units of fire equipment were three units and crews from Halliburton's Blackwell office. Their added pumping capacity was credited with helping bring the $500,000 fire that consumed several buildings under control by midnight. Picture above was taken shortly after units arrived and went into action. View below shows fire breaking out in roof of adjoining building at height of fire. Before fire was under control, some 25 fire-fighting units from 14 Oklahoma and Southern Kansas cities were on hand. Besides Halliburton, the oil industry was represented by equipment from Continental Pipe Line Company at nearby Ponca City, Oklahoma. Photos were taken by Dean Hale, pipe line editor of The Petroleum Engineer, who was visiting his home town of Blackwell at time fire occurred.

Efforts of petroleum industry people in battling the city's biggest blaze emphasized the cooperation of the industry with citizenry. Blackwell has been a center of oil activity for many years.

Beginning in automobile supply and furniture shop, fire soon raged out of control.



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The Use of Emulsions and Related Techniques in the Treatment of Oil and Gas Wells*

Fracturing goes back to early days and a wide range of methods

J. H. PRUSICK and ZANE V. MORGAN

AS early as 1925 certain independent oil producers had experimented with pumping viscous fluids laden with small amounts of river sand into saturated formations hoping to stimulate production.

In those days of relatively low labor costs and high dollar value, the independent producer became an inveterate experimenter. His special delight was in the "resurrection" of old wells. Days upon endless days were spent fishing out "junk", driving lead wool into the bottom of the hole to shut off water, and trying by simple and complex means to coax the wells back to production.

As these patient attempts were made by the geniuses as well as the "crackpots", it is safe to assume that every conceivable technique involving hydraulics was applied and that today there is verily nothing new under the sun.

Records of early fracturing efforts are only sketchy at best, and scant recognition was given to this device until patents were applied for. Attention was then directed to research on the subject, resulting in widespread commercial application.

The mechanism of rock rupture, however, was discussed by Torrey[1] in 1939 and by Dickey and Andresen[2] in 1950. The experience discussed in these papers, most of which antedates the commercial application of the Hydrafrac process, supplied evidence that rocks could be fractured by high fluid pressures, and, undoubtedly, contributed to the development of this process.

In 1949 the Hydrafrac process was developed for fracturing of a formation by injecting under pressure a gelled hydrocrabon such as kerosine or diesel oil, which acted as the viscous vehicle for carrying relatively small amounts of round-grain sand. As the gel was too viscous to penetrate the pore spaces of the formation it rather fractured the formation carrying the sand into the openings so formed. Thereafter, the gel was thinned by an oil flush. The thinned gel returned to the well bore and was recovered, and the sand remaining in the fracture served to prop or hold the fracture open, thus creating a permeable passage for oil.

The hydrocarbons used for formation fracturing were usually gelled with metallic soaps. The large quantity of these soaps necessary to achieve proper viscosity made this service somewhat expensive, and with the ensuing "spotty" field results it lost some of its attraction after a period of acceptance.

A later modification of the method achieved much more consistent results vastly superior to the former attempts. This involved a relatively small amount of hydrochloric acid emulsified with kerosine, the combination of which served very well the dual purpose of fracturing and sand suspension. Although the mixture was loosely called a gel it was actually an emulsion of the oil in water type.

With the advent of this material in 1952, several ghosts which haunted production departments had to be put to flight before further development could come about. The most highly respected of these ghosts was one which had built up universal prestige over a period of many years. Its name was "emulsion." The prospect of persuading the average superintendent or engineer to put an emulsion into his oil wells was indeed very bleak at first. This is one reason why all the early emulsions were referred to as gels for the mere mention of an emulsion struck terror in the hearts of those who at some time or other were deeply concerned with very bad tank bottom problems. It was also evident that emulsion complexes were responsible in many areas for dwindling production. No one wanted to have a formation deliberately fouled up with such material.

Another controversial topic was whether or not the bottom-hole temperature would "break-out" the viscous fluid used in fracturing. Most operators were very firm and united in the opinion that the material should be unstable to their bottom-hole temperatures. How this one opinion gained such importance and widespread acceptance is not known; however, it is a matter of record that some materials were being used in the field with wonderful and consistent results by some operators while other operators were forbidden to use the same material pending evaluation by their laboratories. The reason for this is also unknown. Any thickened liquid that would be thinned or "broken-out" by shallow hole temperatures certainly would not be reliable for transporting with sand in suspension during the summer time periods of hot weather. In this respect heat is a function of time, and if a material were tailored to "break-out" in four hours at a bottom-

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Morgan is a graduate of Lehigh University, and has been with Texas Acidizers, Inc., for the last five years.

*Presented at the 24th annual meeting, North Texas Oil and Gas Association, Wichita Falls, Texas, March 27, 1954.

hole temperature of 140 F, it might also break out in 10 hours from diurnal heating on the surface. Thus, if something unforeseen caused a delay at the well-site, with subsequent "break-out" of the fluid, no immediate service could be rendered, and costly materials have to be thrown away.

While objections to emulsions in general and more particularly to heat stable emulsions were being sustained, the steadily mounting backlog of favorable results achieved through fracturing with these materials finally dispelled such fears. Less and less was said about the possibility of ruining a well with an emulsion fracturing fluid. Furthermore, many "unscrupulous" operators stooped so low as to use dirty, sun-burnt pit oil for their sand supporting vehicle and found that amazing results could be obtained. In some areas it seemed to matter little what was used, just so it suspended the sand. Apparently the faces of a formation fracture are not damaged by contact with certain materials although the same materials may devastate the inner flow system of the same formation; however, it was still believed by many that the oil in water type of an emulsion was an undesirable fluid.

The next development was one that was tailored in one way as a concession to a former objection and in another way as a direct frustration of another objection. This was an emulsion of the water in oil type in which a relatively small amount of kerosine formed the external phase and with hydrochloric acid as the dispersed inner phase. Furthermore, the oil phase carried an oil-soluble surfactant which had the desirable action of oil-wetting the heterogenous reservoir rock surface of the newly opened fracture channels. It also meant that the fracturing sand would henceforth carry a molecular oil coating as well as any formation constituent ranging from siliceous (low pH) to calcareous materials (high pH). This emulsion was stable to temperatures above 220 F. It could be put into storage for indefinite periods without fear of breaking from atmospheric temperature fluctuations. Its sand suspension was excellent. It could be transported with five pounds of sand per gallon for 250 miles before any appreciable amount of sand settled to bottom. Furthermore, the settled sand did not pack as in the case of oil in water type emulsions but rather remained in a fluid mass that permitted the mixing paddles to start easily so that only slight stirring was necessary to obtain a uniform mixture.

This emulsion is one that has been developed primarily for the purpose of imparting favorable chemical action to the producing formations. Heretofore the quest had been directed to emulsions that possessed characteristics that were physically and economically advantageous to the fracture service companies. This recently developed product was aptly named "Molfrac" by the Texas Acidizers, Inc. Its oil-wetting and silicate control action prevents swellable silicates from coming in contact with the aqueous phase during treatment of water sensitive formations. Its viscosity is reduced to that of the crude oil flush, which conveniently brings about this reduction as it mixes with the emulsion in the formation. Its cost is reasonable and compares favorably with the lower priced acid-kerosine emulsions in popular use.

After the first few "Molfrac" applications in the field its advantages were recognized, and, for the past year, its sales volume has steadily increased despite the advent of the cheaper crude oil emulsions that were developed for use as fracturing fluids. A number of case histories bear conclusive evidence that "Molfrac" is a more desirable fracturing fluid in certain formations than other commonly used products and materials.

A remarkable case in particular concerns a 3000-ft field, producing from the Navarro sand, of considerable areal extent wherein excellent comparisons are possible. The producing zone consists of about 9 ft of good porosity and moderate permeability (60-190 mds). The Navarro sand is considered extremely water-sensitive due to bentonitic shale that appears to be generally distributed, as well as locally concentrated in thin laminations. Upon original completion the wells would produce a matter of 6-11 bbl natural. After seven wells had been fractured with the acid-kerosine emulsions in use at that time, the wells would make 21-30 bbl oil per day settled production. Common opinion established the optimum treatment to be 2000 gal of the emulsion carrying 4000 lb sand. These amounts were more or less standard for eight wells. A well was then fractured with a like amount of Molfrac and sand, and this treatment resulted in 49 bbl settled production. Three more wells were then given the same Molfrac treatment, and the average results were 43 bbl per well. Later, three more wells were similarly treated, but emulsified crude oil from the lease was used in these treatments. Two of these jobs resulted in 32 and 37 bbl respectively. The other well sanded-out when less than half the material had gone into the formation and results were not comparable.

In another field where local comparisons are not reliable because of varying structural conditions the average of increases obtained with Molfrac was some 9 per cent higher than the average of increases obtained with other fracturing fluids.

In the case of shaley sands that are sensitive to water, it is not apparent that the faces of fractures can be materially damaged by oil in water type fracturing fluids; however, it is likely that contact of these fluids with the fracture surfaces does swell and disintegrate a considerable amount of the clay material that then sloughs and restricts oil flow within the injected sand body. Such possible occurrence is prevented through the oil-wetting action of the Molfrac treatment.

The most recent development in fracturing fluids is the thickening of crude oils by emulsifications with small amounts of water or acid. This produces an oil in water type emulsion which possesses good physical properties, but because of its external aqueous phase it may be unsuitable for use on some formations. Its main advantage is low cost. The fact that the crude oil can be reclaimed and sold as production makes its cost to the operator very low. In a treatment of this type, the service company brings the sand, water, and emulsifier to a tank battery near the well to be fractured, uses the oil to make up the emulsions, adds the sand, and treats the well. In making up this emulsion it is necessary to add the crude oil very slowly at first, gradually increasing the rate of addition to the final gel. This procedure plus adding the sand plus maneuvering the equipment all takes time, and, in many cases, where expensive rigs and crews are being retained, the advantage of lower cost crude oil fracturing is more than offset by the longer time involved. Another disadvantage is the fact that crude oil emulsions do not support the sand in suspension as reliably as the acid-kerosine preparations. Quite freqeuntly sand-outs do occur, especially in "set-through" completions, whereas successful injection would be achieved with the acid-kerosine prepared emulsions.

Variations to simple fracturing have been developed with wide differences in results. Multiple fracturing for instance involves the use of one or more slugs of highly viscous gel with or without suspended solids introduced at intervals into the fracturing fluid stream. The object is to plug off the openings already formed, and due to this rupturing at other levels in the hole is possible. Continuous flow surveys (spinner) are sometimes taken during this type of treatment which show that the fluid stream can be diverted from one zone to another as the slugs reach the formation. Pressure variations coincide with the activity of the spinner. Apparently, the original rupture is ex-

tended further up or down by this procedure instead of being sealed off and new separate ruptures taking place. It is reasonable to assume that nothing short of a rigid plug such as cement that is bonded cleanly to the formation could possibly seal off an existing fracture and resist pressure to the extent that rupture will occur somewhere else.

The use of a straddle packer has been effective in fracturing more than one perforated section inset through completions. Several sections can be positively fractured, each with a prescribed volume of fracturing materials, by re-setting the tool over each zone individually. The total job is almost a continuous operation.

Regarding the controversy as to whether fracturing creates vertical or horizontal fissures, it is our opinion that overburden is the determining factor as to which type is obtained. We believe that in shallow wells of about 1500 ft or less horizontal ruptures take place. Our reasoning is based upon the fact that after fracturing such shallow holes prodigious amounts of shale are usually recovered in the return flow. This would indicate that the injected sand had scoured a considerable area of this shale which suggests radial progression along a bedding plane. The flow in these wells is usually a rapid-flush of short duration after which a fast decline results with generally poor results in an early period. This suggests merely restitution of the overburden and no interconnecting of two or more productive zones separated by shale.

On the other hand, from about 1500 to 6000 ft the return flow is generally quite free from shale. This leads us to assume that the fracturing sand had not been forced along on extensive shale face and consequently very little shale was scoured loose. Therefore, bedding plane entry is not likely, and, as production increases are generally good in this depth bracket, it is evident that multiple productive sections have been opened up. Vertical fractures are indicated in such cases.

Below approximately 6000 ft generally poorer results are obtained, and it is probable that due to overburden pressures the fractures do not open wide enough to receive a heavy concentration of injected sand to achieve an effective flow system.

Other factors that no doubt do modify the above conclusions must be considered. The stratification of the reservoir rock and any deformation it may have experienced, resulting in the formation of a joint system, will, of course, have some influence on the fracture pattern. Rocks will certainly rupture at their weakest points, and, if this should be along joints, the fracture pattern will probably be vertical; whereas, if definite planes of sedimentation are present, the fractures more likely will follow them and be parallel to them.

Aside from the techniques of formation fracturing, there have been improvements made in other methods of fluid treatment of old and new wells for the purpose of improving the production of oil or gas. Thousands of wells have been acidized during the last two decades in limestone and dolomite formations. More recently, the use of new chemical additives to hydrochloric acid has made it possible to not only improve acidizing methods in general but to permit successful acidizing of sand formations containing calcareous material as well as straight sand formations.

A recently developed product, named Orchem A-40, is being used successfully as an additive to regular hydrochloric acid or mud acid to serve as a silt-suspending aid and as anti-clay swelling agent. The silts and acid insoluble materials released by the acid reaction within the reservoir that normally settle out of spent acid can conceivably cause mechanical plugging within the capillary channels. This additive, as an effective suspending agent, will help in controlling this problem by keeping such solids suspended in the spent acid until the acidizing treatment has been completed and the spent acid recovered.

As bentonitic clays can be flocculated to a fair degree on contact with strong acid, this desirable effect can be further insured by protecting such clay surfaces by the plating out of a protective molecular film on such surfaces.

This chemical film, which is available as a component of Orchem A-40, controls the re-swelling of the clays when they are in contact with spent acid. In addition to these prime functions, this additive also lowers the surface tension of the treating acid and exhibits properties of an emulsion breaker.

A great number of oil wells, both old and new, are not producing at their best potential level because their productive capacity may be hampered by a water block. This water is frequently of foreign origin and may come from a variety of sources such as a water loss from the drilling mud used for completing the well or water from a casing leak. Furthermore, the presence of mud solids or emulsions within the formation and close to the well bore can effectively decrease the productive capacity of a well.

In reservoirs that can be considered as water-wet, the surface conditions normally in existence are such that the wetting phase in contact with the rock surfaces is water and the non-wetting phase is oil. An excess of water within such a capillary system can effectively reduce the relative permeability of the rock to oil. Such a condition may be due to a high percentage of connate water in fairly close promixity to the well bore, which may be caused by normal fluid movement over some period of time. This condition, no doubt, can contribute to the decline in production.

A new reservoir conditioning treatment for oil wells has been developed recently and involves the use of a product named Orchem M-14. This product is a specially designed oil-soluble wetting agent. Its function is to (a) preferentially oil-wet the reservoir capillary surfaces within the treated area and (b) break down and remove water blocks which are affecting efficient oil production.

By preferentially oil-wetting the capillary surfaces of the reservoir rock, the interfacial tension characteristics of both the fluids and the rock surfaces become altered to the point where the relative permeability of the rock to oil will be increased and where the water can be effectively removed due to the lower interfacial tension between the water and the oil. Furthermore, it is reasonable to assume that if the treated area will be preferentially oil-wet the drainage area around the well bore will be effectively increased and the "throttle effect" decreased. The components present in Orchem M-14 are such that they will cause preferential oil-wetting of a heterogeneous rock surface and break existing water blocks by tying up the water in the form of a thin, mobile water in oil type emulsion which then can be recovered from the well.

Service companies are constantly searching for new and improved techniques and products for the purpose of increasing the production of oil.

Off-Shore Seismic Work

Latest to equip for off-shore seismic work along the California coast is International Geophysics, Inc., of Los Angeles, according to Dr. J. J. Jakosky, president. This firm recently purchased, and fitted a fleet of appropriate craft consisting of a 55-ft cabin cruiser for surveyand utility work, a63-ft ship for the seismic recording equipment a 45-ft cruiser, which functions as the shooting vessel, and two 35-ft cruisers for general utility work.

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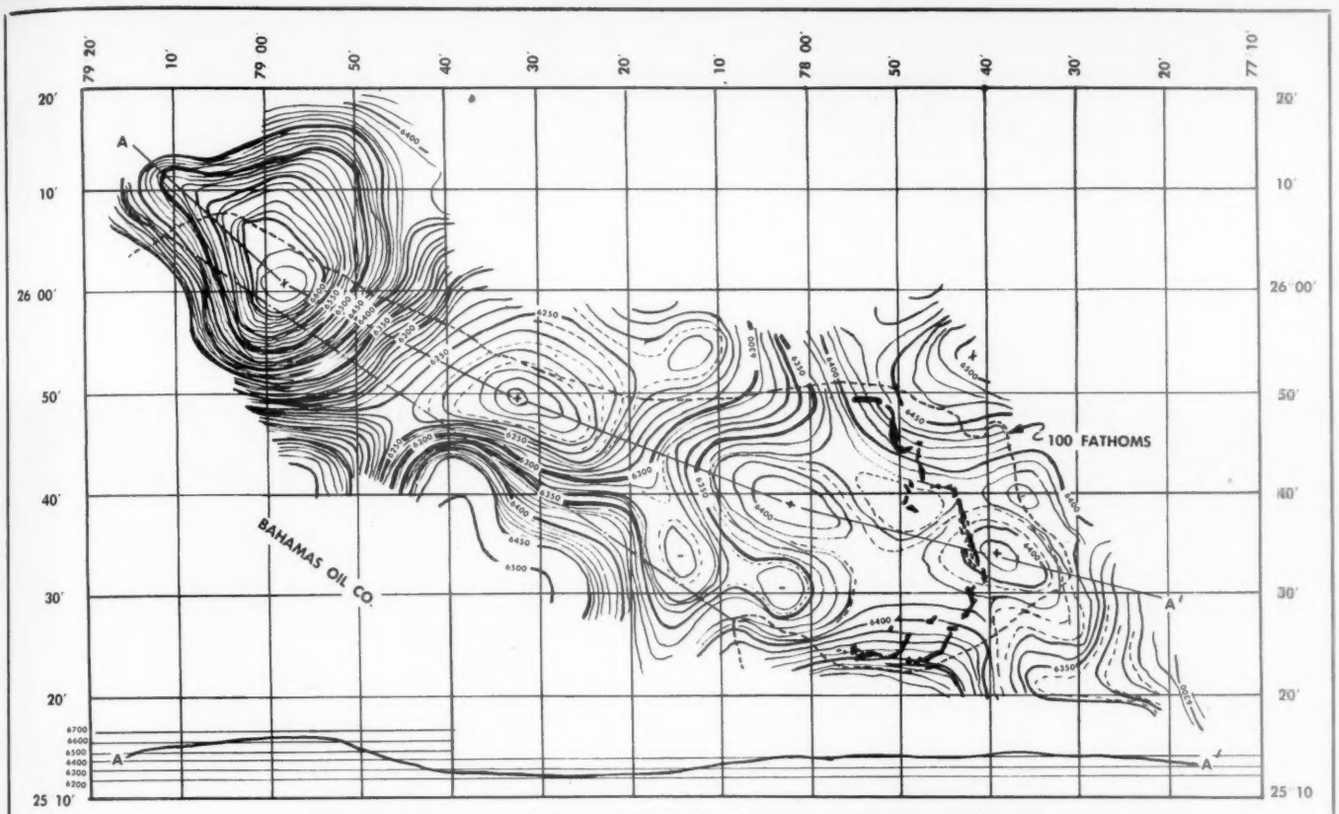

Magnetometer Survey, Nassau Oil Mining Company concession, Bahamas.

OIL EXPLORATION IN THE BAHAMAS

Considerable work is being done in an attempt to bring in commercial quantities of oil in Bahamas

BALTRON B. BETHEL

THREE companies hold oil concessions in the Bahamas. The Bahamas Exploration Company, Ltd. (Gulf) holds three concessions, as follows:

1. **Area "F". An area of 5392 sq miles of land and submarine bank in the Exumas and the Great Bahama Bank.**
2. **Area "E." An area of 3676 sq miles of land and submarine bank in the Exuma Cays and the Great Bahama Bank.**
3. **Area "P." An area of 843 sq miles of submarine bank in the eastern part of the Cay Sal Bank.**

Area "F." Bahamas Exploration is now re-examining its data and is contemplating further geophysical work probably with underwater seismograph equipment.

Because the test well drilled by an associated company on the north coast of Cuba, was a dry hole after being carried to 11,218 ft and the results were not conclusive, that company is now engaged in intensive geological study, which it is felt will have an important bearing upon Area "E." Conclusions from this study should be drawn within the next few months, when the company should be ready to determine what type of geophysical work is warranted to be undertaken on this area.

The same applies for Area P.

Bahamas Exploration has had its concessions renewed for a further period of one year. Purpose of such renewal is to make geological, geophysical, and topographic examinations and to dig and turn up the surface of the land and drill geological information wells.

Nassau Oil Mining Company, Ltd., an exclusive local company, holds one concession, Area A, an area of 1502 sq miles of land and submarine bank in the Berry Islands and Northern Portion of Great Bahama Bank.

Following stages in its oil exploration program have been carried out:

(1) Regional geologic studies of the Bahamas and environs.

(2) Geologic study of the conces-

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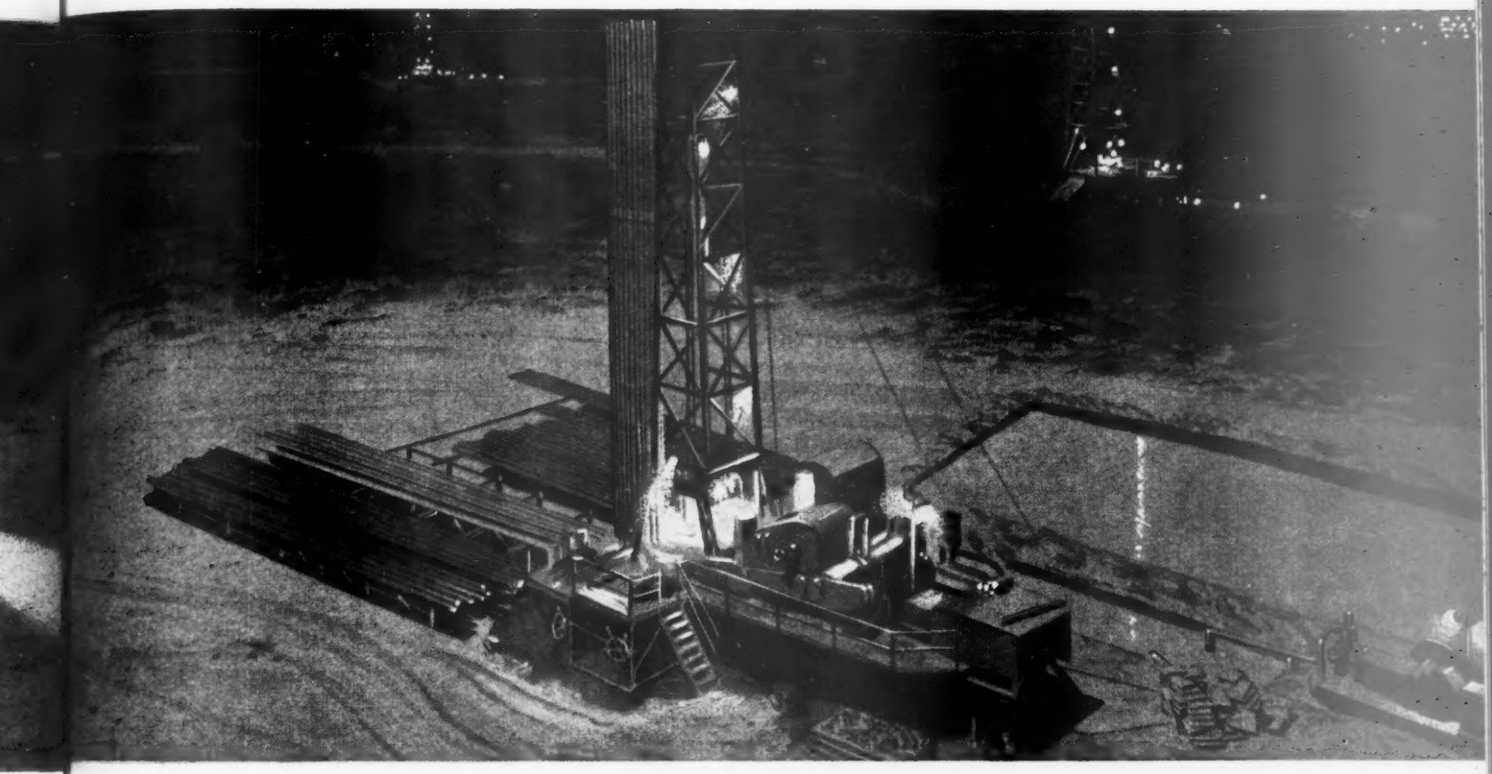

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*An evaluation of figures from a recent survey shows the following: Over 800,000 service calls are made annually by service companies furnishing scientific, engineering and technical services; over 700,000 service calls are made by manufacturers furnishing service with their products; over 5,000 service company crews are constantly working on well jobs; average number of services performed by service companies—17.

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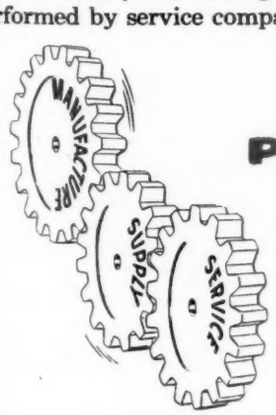

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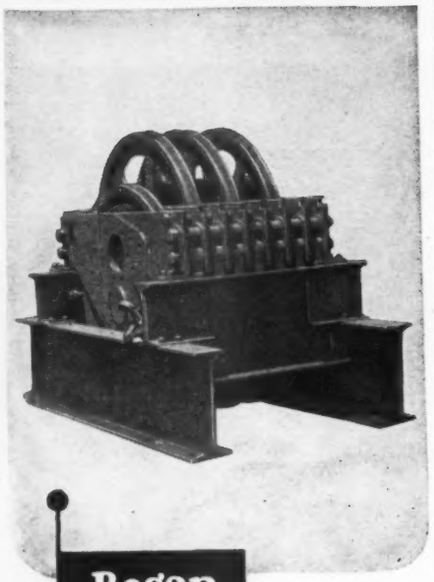

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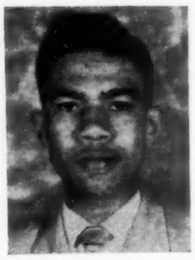

Baltron B. Bethel is secretary, Petroleum Board, and clerk, Attorney General's Chambers, the Bahamas. The young executive, 20 years of age, is a graduate of Government High School, and holder of Cambridge University of London Senior School certificate. He has held his present position since 1951.

sion as a whole as related to its immediate environment.

(3) A thorough and complete surface and submarine examination of the concession.

(4) Geophysical exploration of the concession.

(5) Coordination of all data.

No work has been done with regard to exploratory drilling.

Fish, Samphire, Cockroach, Holmes, Ambergris, and Frozen Cays have been examined, as well as various unnamed islets and rocks. Additional surface investigations have been made on Bond's and Great Harbour Cays. At all of these places surface formations have been studied and described with reference to their attitude and lithology. Rock specimens have been collected from many of them for microscopic study and classification. Unusual surface features such as "ocean holes," small bights, channels, the occurrence of ground water, reported "springs," etc., have been carefully sought out and investigated. As always, particular attention has been given to localities that might show evidences of geologically recent uplift or downwarp, or to any topographic or geologic feature that might indicate faulting or folding of the earth's crust.

Microscopic examination, description, and classification of the large number of rock specimens thus far collected in the Berry Islands has been made. This investigation has been undertaken in the belief that microscopic data may provide information regarding the geologic history of the Berry Islands.

The relationship and trend of axes of the anomalies revealed by the geophysical survey have been studied in an attempt to correlate the magnetic map with theories on the geologic history of the Bahamas. The relationship between submarine contours and magnetic trends has been studied.

No work has been done by the above company for the past two years.

Bahama California Oil Company, Ltd., now holds seven concessions in the Bahamas. Personnel have recently visited the Bahamas in connection with the beginning of their operations.

The company seems optimistic with regard to the outcome of its operations.

Concessions granted to Bahamas Oil Company (Superior) have been cancelled at its request. The company drilled a test hole at Andros, however, after drilling to a depth of 14,585 ft, the test was abandoned. Section penetrated was predominately limestone and dolomite with no commercial shows reported in any of the 66 cores cut. Difficulties of the operation are revealed by the summarized drillers log.

Area of survey, Great Bahama Bank.

Driller's Log

Bahamas Oil Company, Ltd.

ANDROS

Location: 24°52'37 .2" N
78°01'54 .7" W
Stafford Creek — Andros Island
Bahamas — B.W.I.

Elevation: 19.5' Derrick floor
4.5' Ground

Spudded: 11.45 a.m. 4/13/46

Completed Drilling: 4/1/47

Plugged and Abandoned: 4/27/47

Casing Record: 18⅝" cemented @ 396' with 400 sx
13⅜" cemented @ 2220' with 1351 sx
9⅝" cemented @ 6498' with 1750 sx
7" cemented @ 11393' with 750 sx

Remarks:
Lost circulation at 70'
Regained circulation at 399 after running 18⅝" casing
Lost circulation at 540'
Regained circulation at 2220 after running 13⅜" casing
Lost circulation at 2689'
Regained circulation with water at 4220.
Lost mud circulation at 9604'
Regained circulation with water
Lost circulation with water at 10,020'
Stuck pipe at 11,347' while drilling at 11,365'
Pipe parted at 10,775' while coming out of hole.
Sidetracked pipe and drilled to 11,393' where 7" casing was cemented.
Regained circulation with mud after cementing 7" casing at 11,393'
Lost circulation with mud at 12,965' and Regained circulation with Fibertex.
Lost circulation with mud at 13,230'
Regained circulation with high viscosity mud and Fibertex at 13,290'
Lost circulation with mud at 13,385 and Regained circulation with water at 13,385
At total depth of 14,585' Kelly sub parted allowing drill pipe to drop.
Found top of fish at 8,062.34'
Recovered drill pipe between 8,062.34' and 10,687'
Could not recover the remaining drill pipe lost in hole.
Well plugged and abandoned. ★ ★ ★

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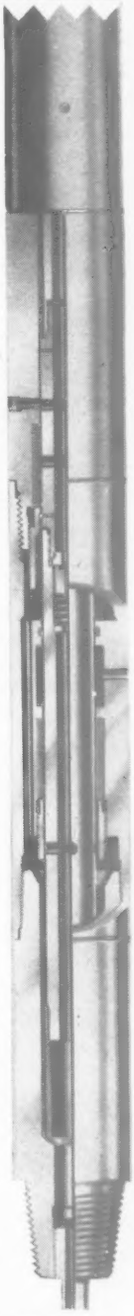

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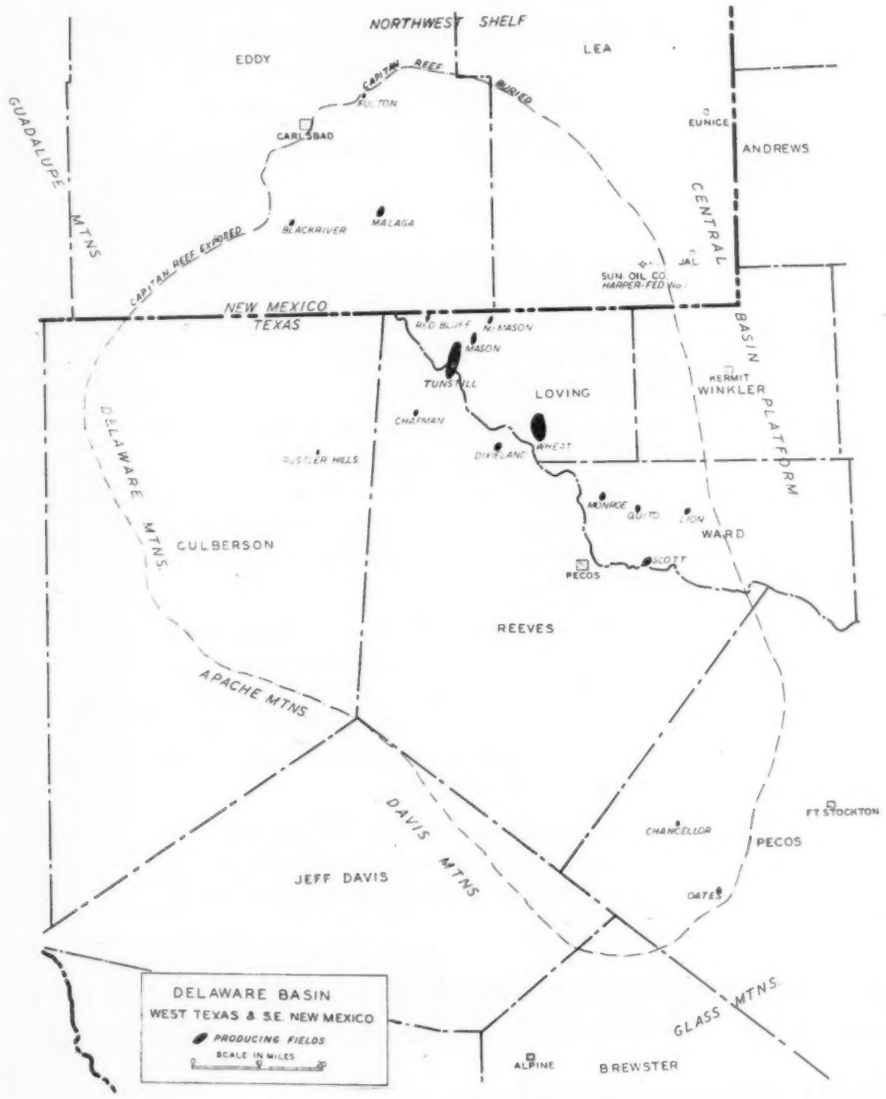
BEND ZONE IN DELAWARE BASIN

New Mexico wildcat surmounts numerous problems in deep exploration into Pennsylvanian formation

D. C. BROWN

SUN Oil Company assumed operating control of a previously abandoned wildcat, W. E. Harper No. 1, situated 660 ft from the south and east lines of Section 26, Township 25 South, Range 36 East, Lea County, New Mexico, on May 12, 1952. General American Oil Company had spudded the test and carried it through the Delaware sand zone of the Permian. The well is 8 miles west of Jal, New Mexico, with a surface location above one of the deepest portions of the Delaware Basin. Sun took part interest and operating control in order to make a test of the Devonian formation.



Delaware basin of West Texas and Southeast New Mexico.

Original hole had been drilled to 6055 ft, without encountering any shows. Thirteen and three-eights inch surface casing was cemented at 370 ft with 140 sacks, and 9⅝-in. casing was cemented with 210 sacks at 5082.

A contract rig moved in for Sun, and after drilling out a cement plug from 5042-5160, washed to 6055 and began drilling an 8¾-in. hole.*

From May 27 to August 30, the well was drilled from 6055 to 11,669 ft. No difficulties were encountered in this period; the 8¾-in. rock bits drilled an average of 50.2 ft per bit, and the average daily footage drilled was 61.7. Cores from 6977-7002 indicated fluorescence without porosity. DST's taken are listed below:

1. **7316-30** **Rec 5 ft mud, no show.**
2. **7693-736** **Rec 38 ft mud, no show.**
3. **8470-97** **Rec 272 ft gas cut mud, no show oil or water.**
4. **8560-600** **Rec 2070 ft gas cut mud, no show oil or water.**

On August 30, 1952, the well had reached a depth of 11,669 ft in the Bone Springs formation. There was a slight drilling break at 11,659 and shows of oil and gas appeared in the mud. Mud weight was raised from 9.1 to 9.4 lb per gal by tenths after the well began to kick, with the increased mud weight holding the well in check. A core was taken from 11,669 to 11,679 ft with a recovery of 2 ft of black shale containing several brownish gray lime stringers approximately ⅛-in. thick, and 8 ft of black shale with a good gas

*The rig had a 136 ft derrick with a National 100 drawworks powered by three 350 hp LRO Waukesha engines.

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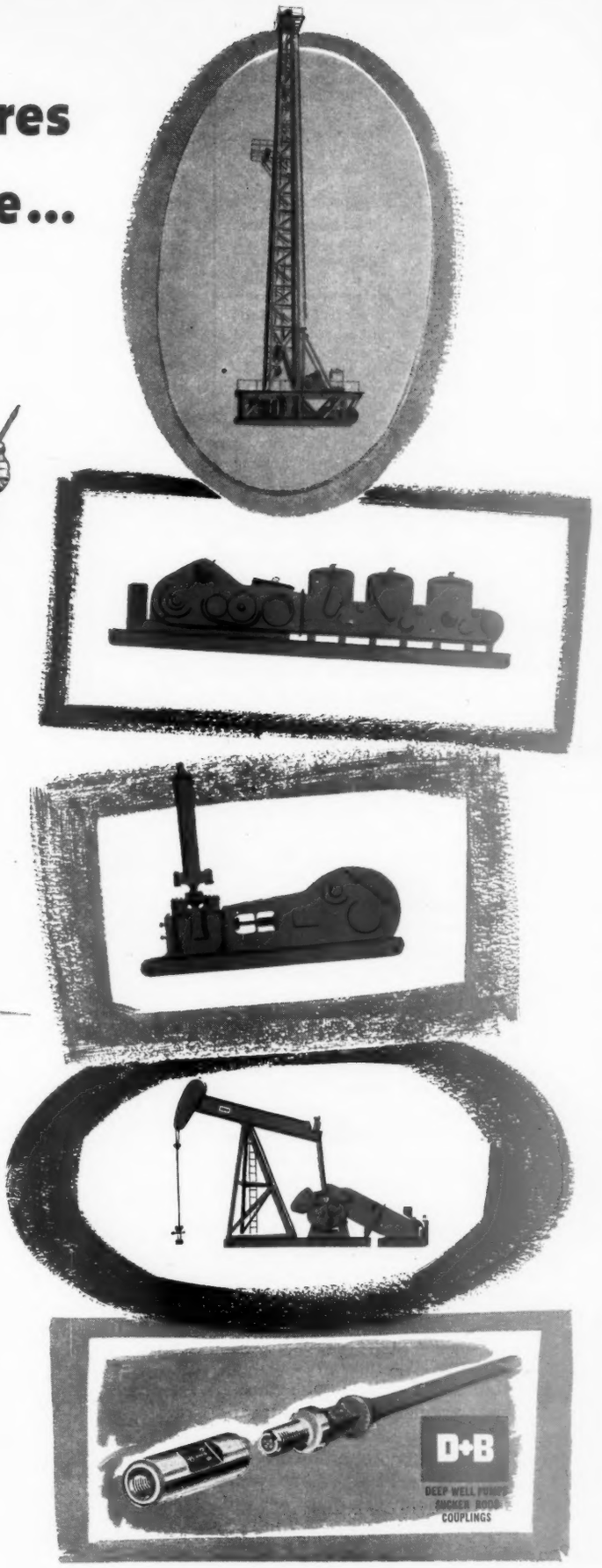

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The Author

D. C. Brown is district engineer of West Texas and New Mexico for Sun Oil Company. A graduate of Texas University, he has worked for Sun since his graduation in 1947. Since he joined the company, Brown has been an engineering trainee in Robert Lee and Odessa, junior engineer, at Odessa and Snyder, and field engineer in Midland. He was named to his present position in 1952.

odor. Mud weight was again increased by tenths to 9.6 because the lighter mud was becoming gas cut.

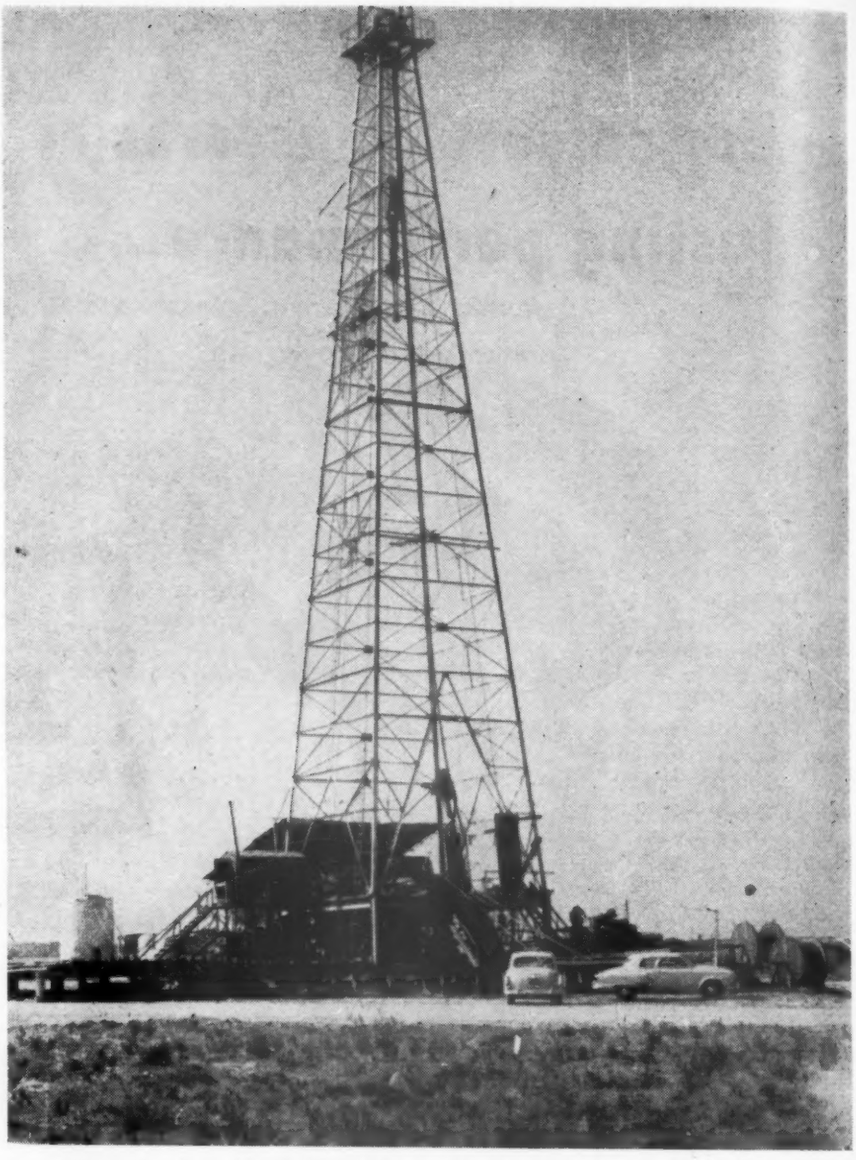
A drill stem test was taken from 11,656 to 11,679 ft which recovered 3600 ft of clean oil and 75 ft of oil and gas cut mud. The bottom hole pressure open was 1575 and the bottom hole pressure after a 15 minute shut-in was 5970, with a recorded hydrostatic pressure of 6200 psi. Since 11,679 ft of 9.6 lb per gal mud will exert a hydrostatic head of 5830 psi, and since the recorded hydrostatic pressure on the drill-stem test was 470 psi greater than that, it is believed that the mud was gas cut as weighed and the compression of this gas in the hole gave a mud with a true weight slightly over 10.2 lb per gal.

The well was cored from 11,679 to 11,691 ft with a recovery of 10 ft, 8 in. which included 6 ft, 2 in. of hard crystalline dark brown limestone with vuggy and cavernous porosity, bleeding oil and gas.

The well kicked while the core was being cut, and when mud weighing 10.3 to 10.5 lb per gallon was pumped in the drill pipe, the formation started taking fluid. Mud weighing 10.0 lb per gallon, containing fibrous lost circulation materials was then pumped in to regain circulation.

The next six days were spent in conditioning mud, reaming the 6⅛-in. core hole to 8¾-in., and running electric logs. Control of the mud during this period was anything but easy since 10.0 mud would come out gas cut to 8.8; 10.1 and 10.2 mud would come out gas cut to 9.7 or 9.8, while causing some lost circulation problems; and mud weighing 10.3 or higher caused drastic lost circulation problems with the additional problem of the well's kicking if the hole were not kept full.

On September 9, 1952, the 7-in. casing was run with the seat at 11,691 ft, and cemented with 205 sacks of 4 per cent gel cement plus 50 sacks of perlites. There was no circulation during the cementing operations, and a temperature survey was run, which indicated no cement outside of the 7-in. casing above 11,650.



Rig on location at Sun's W. E. Harper No. 1 in Lea County, New Mexico.

Casing was perforated from 11,300-2 ft with 4 jet SPF, and these perforations were squeezed with 90 sacks of slow set cement containing 4 per cent gel in an attempt to insure a good cement job. Twenty-five pounds of radio-active carnotite was mixed in the cement in order that the location of the cement might be checked by comparison of Gamma Ray-Neutron logs run before and after the squeeze.

The first squeeze job was not successful in giving a shut-off after drilling out, and was followed by other squeeze jobs listed:

No. 2. 500 gal mud acid, followed by 95 sacks of slow set cement containing 4 per cent gel and 35 lb of carnotite. No shut off.

No. 3. 500 gal mud acid, followed by 194 sacks slow set cement plus 65 lb of carnotite. No shut off.

No. 4. 500 gal mud acid, followed by 50 sacks of slow set cement. No shut off.

No. 5. 500 gal mud acid, followed by 50 sacks of Trinity Inferno. Cleared tool and perforations with water when squeeze pressure did not build up.

No. 6. 20 sacks of Trinity Inferno. No shut off.

No. 7. 500 gal mud acid, followed by 75 sacks of 1:1 mixture of slow set and Pozmix containing 2 per cent gel.

On the seventh squeeze a shut-off was obtained, and the casing was cleaned out to bottom. The casing was perforated from 11,662-9 ft with 29 bullets and from 11,681-9 with 29 bullets; then 2½-in. EUE tubing was run

for completion with a Brown Duo-Pac packer set at 11,635 ft after the mud in the tubing had been displaced with water. After a 2-hour shut-in to connect the necessary surface connections, the tubing-head pressure was 1425 psi, indicating a formation pressure of about 6450 psi.

The well was flowed into the tanks on October 23, and for a few hours flowed at rates of better than 20 bbl oil per hour with no water, and at a gas/oil ratio of 1000/1. A definite decline in capacity, however, was apparent during the second day of testing and the well died. After several days of swabbing and flowing increasingly smaller amounts of oil, the well was acidized with 500 gal of mud acid, to which the well did not respond.

The casing was reperforated from 11,681-9 ft and 11,661-9 ft with an open-hole type glass perforating gun, and these sections were reacidized with 5000 gal. No response was achieved. Another 12,000 gal acid treatment was performed using a low-surface-tension hydrochloric acid. Following this the well showed some life, flowing 90 bbl by heads, then died. Five days of swabbing saw a continuously lowering fluid level and discouraged further attempts at this depth.

It was then decided to drill the well deeper with a 6-in. hole and drilling was again begun after cleaning up the hole and obtaining circulation with clear water.

The section from 11,691 to 11,701 ft was drilled while cleaning up the hole. Cores were taken from 11,701-11, 11,711-40, 11,740-67, and 11,767-93 ft. Cores indicated shale with interbedded lime stringers that did not warrant further testing, although some of the lime stringers did bleed a slight amount of gas.

Drilling progressed rather smoothly from 11,691 to 13,331 ft using 6-in. bits and 2⅞-in. drill pipe. The drilling fluid used during this period was water with a small amount of gel, and the mud weight was 8.6 lb per gal. A Sperry-Sun Multi-Shot Directional Survey was run from surface to 11,690, and drillstem tests and cores were taken as listed below:

Cored	Recovered
12,013-33	Black shale and brown lime, bleeding slight amount of gas.
12,951-76	Tannish lime and black shale, with 10 in. of the shale bleeding a slight amount of oil.
13,053-73	Black shale and 2 ft of lime, no show.
13,073-103	Black shale and 1 ft 3 in. of lime, the lime showing good fluorescence and odor.
13,125-58	Black shale and gray lime, no show.

DST's

12,670-92	2500 ft water cushion and 160 ft of slightly oil and gas cut mud. Had 5000 ft of gas in drill pipe. Bottom hole pressure closed 1350. Bottom hole pressure open 1300.
12,930-50	2500 ft water cushion, 10 ft heavily oil and gas cut mud, 45 ft of clean 40 gravity oil, and 180 ft of slightly oil and gas cut mud. Bottom hole pressure closed 1170. Bottom hole pressure open 1160.
12,980-13,073	2500 ft water cushion and 180 ft drilling mud, no show.
13,204-302	2500 ft water cushion and 930 ft drilling mud. No show.

When the section from 13,325-31 ft was drilled the well began to kick. The mud weight was increased by tenths to 10.4 before the well was again under control. On drillstem test, the section 13,320-31 ft flowed gas at rates up to 540,000 cu ft per day. Recovery was 1850 ft water cushion and 5670 ft gas cut drilling mud. Bottom hole pressure

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To obtain more information on products advertised see page E-57

open was 2025/3325, and bottom hole pressure closed was 6865. A core from 13,331-59 ft recovered gray lime with streaks of black shale, with no show.

The well began kicking again at 13,397 ft and 11.1 lb per gallon mud was required to keep the well quiet.

A drilling break was encountered at 13,409 ft and the mud was weighted to 12.1 to keep things under control.

Cores were taken from 13,418-48 and 13,472-502 ft which recovered brown lime with no show; a core from 14,089-109 ft showed gray and brown lime and black shale with no show; and a core from 14,698-719 ft showed black calcareous shale with no show.

Formation from 13,331 to 14,993 ft was drilled slowly and there were several drilling breaks and gas kicks which were not tested during the drilling operations. Diamond "outside step" drilling bits were used in an attempt to speed the drilling rate and reduce the footage cost when drilling at a depth of 14,000 ft. The experience gained with 3 diamond bits indicated a slight advantage for these bits in shale and lime that contained no chert. Where chert was encountered in the formation, the diamond drilling bits were not as effective as rock bits.

The mud weight was increased from 12.2 to 13.1 at 14,214 ft; from 13.1 to 14.2 at 14,641 ft; from 14.2 to 15.0 at 14,842 ft. Each increase was caused by the well's kicking and cutting the lighter mud with gas. Because a great deal of trouble was encountered in getting the gas out of the mud, a de-gasser was installed at 14,884 ft, and this installation greatly simplified the mud problems. The mud was subjected to a vacuum as it passed through the baffled cylinder. Tests run at the well indicated very good results with gas cut mud weighing 14.0 lb per gallon restored to its full weight of 15.0 lb per gallon on one run through the degasser.

When the mud weight reached 15.0 lb per gallon several sections were drilled that thiefed the mud, and it was decided that this well had gone far enough at a depth of 14,993 ft in the Bend formation.

In order to test the various indicated porous zones in the hole below the 7-in. casing seal, a 5-in. flush joint liner was run from 14,993 to 11,235 ft and cemented with 300 sacks of Trinity Inferno cement containing 2 per cent gel.

Five zones were tested using wire line setting equipment to run and set production packers and bridging plugs. This type of service saved considerable time and expense at the depths at which the work was done.

The zone 14,775-831 ft in the Bend was perforated with 4 jet SPF and tested at gas rates up to 870,000 cu ft per day with no oil. This zone bled down rather rapidly, however. An acid treatment was attempted, but was abandoned when the acid could not be injected into the formation at 6000 psi. The zone was isolated by setting a bridging plug at 14,698 ft.

The next higher zone from 13,941-60 ft in the Bend was perforated with 4 jet SPF and swabbed heavily without making any oil and only an insignificant amount of gas. The zone was isolated by setting a bridging plug at 13,900 ft.

The third zone from 13,382-426 ft in the Strawn was perforated with 4 jet SPF and it showed no oil and only a small volume of gas on swabbing tests. The zone was isolated by setting a bridging plug at 13,355 ft.

The fourth zone tested was perforated with 4 jet SPF from 13,321-41 ft in the Strawn. The zone flowed gas at small rates, with the rates declining rapidly. The well would build up to 1600 lb surface pressure after 3 or 4 hours shut-in, but drew down rapidly when flowed. This zone was isolated by setting a bridging plug at 13,265 ft.

A fifth zone from 12,900-44 ft in the Hueco was perforated with 4 jet SPF, and acidized with 1000 gal. The zone tested only very small amounts of gas. The zone was isolated by setting a bridging plug at 12,840 ft.

The last zone from 12,314-38 in the Wolfcamp was perforated with 4 jet

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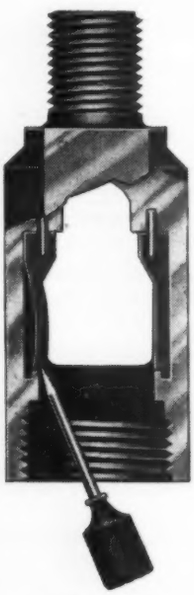

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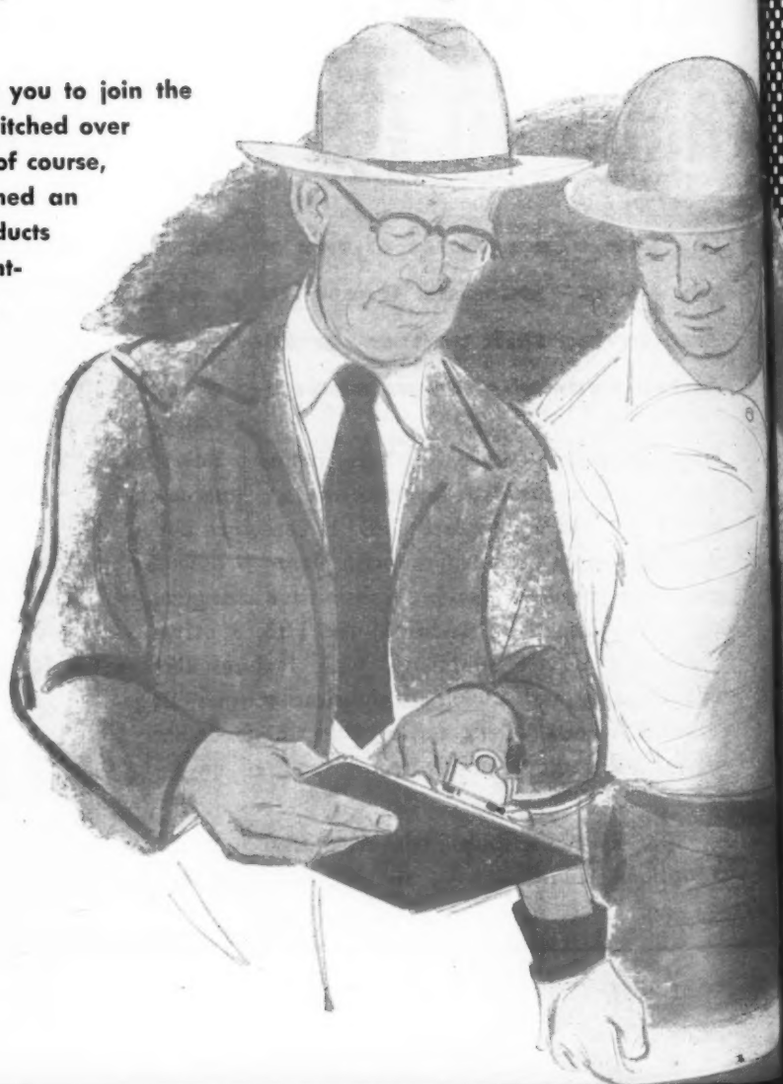

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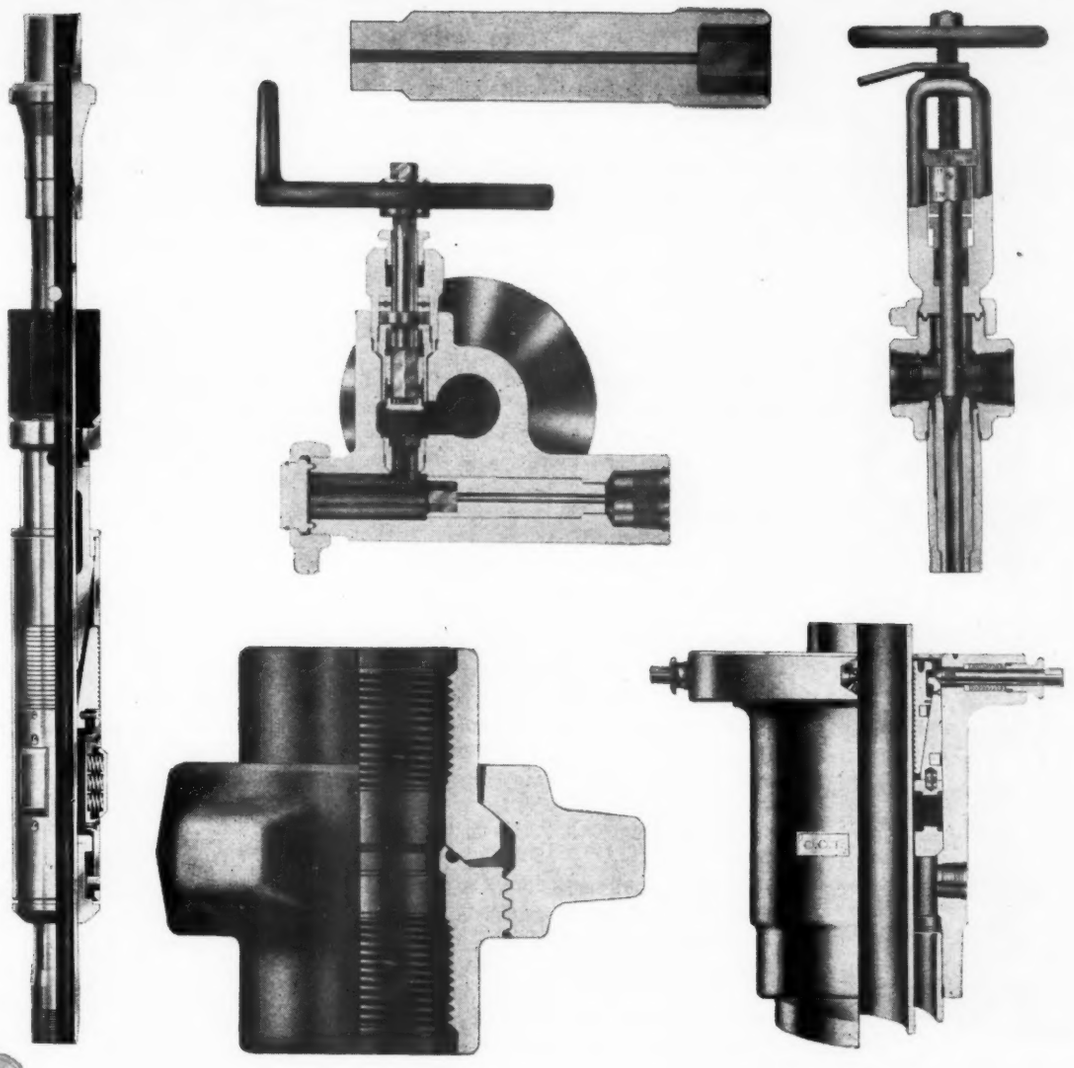

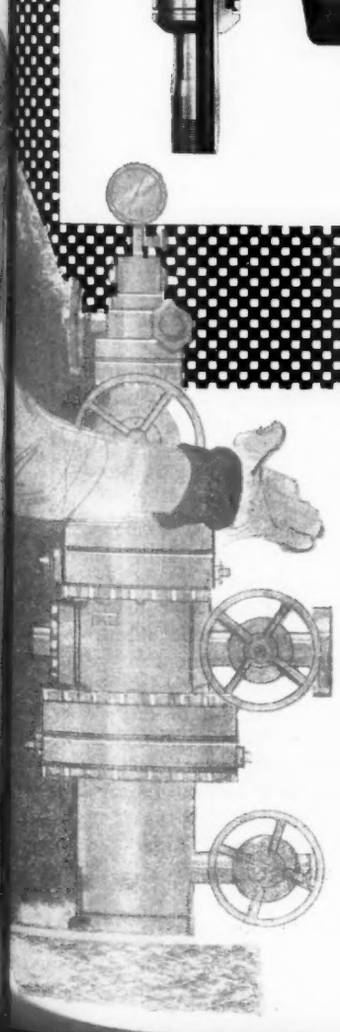

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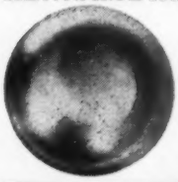

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SPF. The tubing was swabbed down to 8200 ft with no shows of oil or gas. This zone was isolated by dropping a cast iron trip bob to set in the production packer set at 12,291 ft.

At this point, all of the zones considered worth testing in the well had been tested, but there still existed some doubt as to the results of the tests on the zone from 11,660 to 11,691 ft.

In order to make sure that nothing was being omitted, it was decided to drill a directional hole from 10,500 to the zone at 11,660-91 ft and retest. To insure that the casing would not unscrew while a 20-ft section of the 7-in. casing was being cut out, the casing was perforated from 10,600-2 ft and the perforations squeezed with 500 gal of mud acid followed by 140 sacks of Trinity Inferno cement. A temperature survey indicated the tops of the cement at 10,500. The casing was perforated from 10,500-2 and these perforations were squeezed with 500 gal of mud acid followed by 140 sacks of Trinity Inferno cement.

After the casing had been cut at 10,530 ft, however, and 4.5 ft of the casing from 10,530-4.5 had been cut out, a 4-ft nipple and collar backed off and fouled the cutting knives. No additional casing could be cut although several sets of knives were run in vain attempts to get a 20-ft section cut out through which to whipstock the proposed new hole.

Flake graphite was added to the mud system during the cutting operations in an attempt to decrease drill pipe drag and torque. The graphite was added in the ratio of 4 lb per barrel of mud, and some reduction in drag and in rotary backlash was experienced.

The window cutting procedure was abandoned and a Kinzback whipstock was run and oriented at 10,465 ft. A conventional type window was milled in the 7-in. casing from 10,465 to 10,476 ft. The section milled was 110,000 psi minimum yield casing and the conventional mills made very slow time. After spending 5 days in milling 5 ft, a concave diamond drilling bit was used to drill out the remaining 6 ft of the window in 25½ hours.

A 6-in. hole was drilled from the window to 11,770 ft using only one whipstock in the open hole. The rate of deflection was controlled by varying the use and number of the drill collars in the hole and by using a stabilizer at times. The deflected hole at a vertical depth of 11,691 ft was approximately 230 ft north and east of the cased hole at the same depth.

There was significant difference, however, in that the well did not kick 9.5 lb per gallon mud, and the cuttings did not show any significant amount of fluorescence in the deflected hole. Swabbing tests of the entire open hole indicated only small gas shows, even after the fluid level had been lowered to 7300 ft. The deflected hole was then deepened to 11,848 ft, with no shows in the cuttings.

The rig was released and the well temporarily abandoned on September 15, 1953.

A comparison of the logs of the regular hole and the deflected hole shows definite erratic thickening and thinning of the shale and lime zones in comparable sections drilled in both holes.

Formations penetrated were, in order:

Formation	Tentative Tops
Permian	
Rustler Anhydrite	*725*
Salado Salt	*949*
Cowden	*3,110*
Castile	*3,915*
Delaware Lime	*5,073*
Delaware Sand	*5,111*
Cut-Off Shale	*8,663*
Bone Springs	*8,690*
Wolfcamp	*12,020*
Hueco	*12,746*
Penna.	
Strawn	*13,311*
Bend	*13,630*

Summary

The Sun W. E. Harper No. 1 was an interesting deep test in the Delaware Basin drilled to a total depth of 14,993 ft in the Bend formation.

The Bone Springs formation contained a zone with high pressure and low volume from which oil was produced for a short time only, and no other sections capable of producing oil were found. At least one section in each of the Hueco, Strawn, and Bend were found to contain gas; however, none of these sections indicated an ability to produce enough gas to make a commercial well.

The abnormally high formation pressures encountered were most unusual, and not expected in West Texas or New Mexico operations.

The erratic thickening and thinning of comparable zones drilled by both the regular and the deflected hole in this well indicate that this portion of the Delaware Basin will not be easily contoured, drilled, or tested.

Experience gained in working with lost circulation problems, abnormally high formation pressures, unusual mud problems, the mud de-gasser, diamond drilling bits, graphite mud additives, wire line setting equipment at deep depths, the cutting-out of a section of casing with knives, the milling of a casing window with conventional mills and a diamond drilling bit, and deflectional drilling give some idea of the complexity of the problems that may be encountered in deep drilling in the Delaware Basin. * * *

Self-Interest Appeal for Accident Prevention

This safety program resulted in a 40 per cent reduction in operating accidents in its first three months of use by a drilling contractor

GENE GRAHAM

EVERYONE will agree that accidents in industry are a tragic waste of productive manpower and potential wealth, in addition to the suffering involved for the victim and his family. In a hazardous line of business like oil well drilling, any possible reduction in the excessive expense for insurance premiums is so much added to the profits. The mere process of reducing the accident ratio of a company or an industry is therefore not only a humanitarian obligation, but one of good management. The reduction of waste spells net gain for any business.

Why do accidents continue to occur, if not increase, beyond the average of mere chance if there is net profit in their avoidance? The answer seems to lie in the human factors involved, and the remedy seems to be in dealing directly with those factors. Rather than continually devising means to protect the individual from the results of his own carelessness or indifference to danger, it would seem that enlisting his cooperation to avoid the occasion of accidents should bring better results than have been hitherto obtained by making rules or setting up mechanical safeguards alone.

The problem of enlisting the cooperation of the average worker to avoid accidents, however, is a hard one, and for the strange reason that the average healthy man cannot easily think of himself as involved in an accident. Bullets in warfare and accidents in industry are always for the other fellow. "It can't happen to me" is almost a universal human attitude, and one that is responsible for the heavy accident toll, hence it is a definite factor in any approach to the problem of reducing the number of casualties in industry.

In April 1953, we initiated a safety program in which this human factor was a major consideration and the results have indicated that our direct efforts to make the worker see himself in the accident picture have uncovered one of the most important appeals that can be made.

The Author

Gene Graham is vice president and general manager for Thomas P. Pike Drilling Company. He was graduated from California Institute of Technology, and joined Baker Oil Tool Company in 1935. Six years later he became a plant manager for the Grant Tool Company, and in 1948 became assistant to the president of the Rocky Mountain Drilling Company. He accepted his present position in 1951.

The program was organized under the direction of our Ben West, assistant to the drilling superintendent. Working in collaboration with a representative of our insurance carrier, a scientific study was made to determine the causes of accidents in our operations by collating information from past and current records of the 16 drilling rigs that the company was operating. Study of the data indicated a definite pattern of causation, and a recurrence of certain types of preventable accidents. A series of meetings was then held with the firm's drillers and toolpushers in which West's findings were laid before them and discussed.

These crew conferences resulted in an accident investigation report form, which is the basis of our present and continuing safety campaign and one of the reasons why we have been able to reduce the average number of injuries by 40 per cent since it started.

Accident Investigation Report Form

The Accident Report Form which was evolved from a study of past accident records is worthy of note at this point, since it lists 14 major causes of accidents, all but two of which have to do with the human factors involved. (See Fig. 1.)

They are:

- Faulty instructions
- Inability of employee
- Poor discipline
- Lack of concentration
- Unsafe practice
- Physical hazards
- Defective equipment
- Unsafe structure
- Physically unfit
- Mentally unfit
- Improper working conditions
- Poor housekeeping
- Improper planning
- Improper apparel

The other parts of the form which are to be checked describe the type and location of the injury.

These forms are to be filled in by both the driller and the toolpusher on the job and forwarded to the main office after the toolpusher has written in his recommendations for prevention of future accidents of this kind. And they must be signed by both the driller and the pusher. These forms, be it noted, have the double function of collecting information for study, and also of making the causes, and the responsibility for the accident a matter of record. The psychological effect of placing the responsibility where it belongs in the form of a permanent record has of course had the effect of making all those involved more alert to the matter of safety measures and the results have been impressive.

These reports are recapped for study at the monthly safety meetings where drillers and pushers are present, after which they are relayed to all drillers and pushers in the organization.

The How of Accident Prevention

Assuming that a worker is not an "accident prone" our program has proved that it is possible to prevent a large percentage of industrial accidents by educating the individual worker to habitually take certain pre-

EXCLUSIVE

THOMAS P. PIKE DRILLING COMPANY

Accident Investigation Report

EMPLOYEE'S NAME..... STREET ADDRESS.....

AGE..... OCCUPATION..... CITY..... STATE.....

WELL NAME..... RIG NO..... LOCATION.....

DATE OF ACCIDENT..... TIME..... ☐ A. M. ☐ P. M. MARRIED..... SINGLE.....

Check Items	CIRCUMSTANCES OR CAUSE OF INJURY
	1. STRUCK BY OBJECTS: Tongs, Elevators, pipe, spinning chains, (no free falling objects)
	2. CAUGHT IN, UNDER OR BETWEEN OBJECTS: Pipe, tong, elevator, latches, catlines, sheaves, etc. (no machinery)
	3. FLYING OBJECTS: Mostly steel particles (and eye injuries) from acts of hammering, grinding, etc.
	4. FALLS (AND SLIPS) ON SAME LEVEL: Stumbling, tripping, slipping on or over odd objects, oil, water, mud, etc.
	5. MUSCULAR OVEREXERTION: Mostly abdominal and back strains from lifting
	6. HAND TOOLS: Mostly wrenches and hammers
	7. BURNS: Mostly welding (Ray), burns of eyes and burns from exploding gas – rest miscellaneous
	8. HARMFUL SUBSTANCES: Acid, lime, drilling mud, caustic soda also inhaled gases or fumes.
	9. STRUCK AGAINST OBJECTS: Most hand injuries, (cuts, punctures, etc.) from handling pipe, etc.
	10. FALLS FROM HEIGHTS: Derrick floors, pipe racks, sub structures into cellars, from trucks, etc.
	11. MACHINERY: Mostly catheads, belts and pulleys, engine fans, mud pump packing glands, etc.
	12. FREE FALLING OBJECTS: Tools, bolts, braces, thribble boards, other misc.
	13. ALL OTHER ACCIDENTS: Motor vehicles, electric shock, heat exhaustion, sunstroke, etc.

Check Items	PART OF BODY Right ( ) Left ( )	
	201 Scalp	HEAD
	202 Forehead	
	203 Face	FACE
	204 Nose	
	205 Mouth	
	206 Teeth	
	207 Ears	
	208 Jaw	
	209 Eyes	
	220 Neck	TRUNK
	221 Shoulder	
	222 Chest-Ribs	
	223 Abdomen	
	224 Back	
	225 Groin	
	226 Hips	
	230 Arm-Upper	ARM
	231 Elbow	
	232 Forearm	
	233 Wrist	
	240 Hand	HAND
	241 Finger– 1, 2, 3, 4, 5,	
	250 Thigh	LEG
	251 Knee	
	252 Shin	
	253 Ankle	
	260 Foot	FOOT
	261 Toes– 1, 2, 3, 4, 5,	
	280 Unclassified	

Check Items	NATURE OR TYPE OF INJURY
	301 Abrasions
	302 Amputation
	310 Blister
	311 Bruise
	312 Burn
	320 Concussion
	321 Crushing
	322 Cut
	330 Dislocation
	340 Foreign Body
	341 Fracture
	342 Fumes effect
	350 Heart condition
	351 Hernia
	360 Infection
	361 Inflammation
	362 Internal Upset
	370 Laceration
	380 Pain & ache
	381 Puncture Wound
	390 Sprain
	391 Strain
	392 Shock
	393 Swelling
	399 Multiple
	355 Miscellaneous Describe:

FIRST AID ☐ ☐ Sent to Doctor..... Name Address ☐ Lost time, if known: _____

☐ Sent to Hospital..... Name Address ☐ No Lost Time

REMARKS: (Give brief description of what employee was doing when accident occurred):

TO BE COMPLETED BY DRILLER – Analysis of Cause

.....Faulty Instructions	.....Lack of Concentration	.....Defective Equipment	.....Mentally Unfit	.....Poor Housekeeping
.....Inability of Employee	.....Unsafe Practice	.....Unsafe Structure	.....Improper Working Conditions	.....Improper Planning
.....Poor Discipline	.....Physical Hazards	.....Physically Unfit		.....Improper Apparel

Were any safety rules violated?.....

Driller's recommendations for prevention of future accidents of this kind.....

Date of report..... Driller's Signature.....

Pusher's recommendations for prevention of future accidents of this kind.....

Date..... Pusher's Signature..... ☐ Regular ☐ Night ☐ Relief

COPY 1

FIG. 1. Investigation report form instrumental in reducing accident frequency.

cautions and to check for certain conditions before proceeding to act. We had better face the general fact, however, that simple admonitions and restrictive rules are not enough. There has to be a motive or a reward that will appeal to the self-interest of the worker aside from personal danger. Failure to note that fact seems, to this writer at least, to be one of the main causes of failure in safety programs. Furnishing a motive was part of our plan of attack on the problem.

For several years, in an effort to make employees aware of the menace of accidents in our business, we published monthly reports of company casualties in our house organ, The Monthly Tour, describing each case, giving the employee's name and listing the means of avoiding a repetition of the event. The results were not outstanding, apparently for the "it-can't-happen-to-me" reason. We became convinced that such a general approach to the whole body of the field workers was not personal enough and involved too little responsibility for those concerned, as well as too little interest on the part of those who read about it.

We decided that the point of self-interest which was common to all employees in regard to the losses from accidents lay in the company profit sharing fund. Our firm operates under a plan of Incentive Management with Profit Sharing whereby eligible members of the personnel share in the profits of the business and have a voice in the management as well. Any losses from excessive casualties tend to reduce the profit sharing fund; in turn savings over the normal expense of protection add that much to the net profits of the business, a percentage of which goes to the fund. Everyone thus has a direct interest in seeing that accidents are held to a minimum. Obviously they would be willing to cooperate, but they had to have the matter brought home to them in terms that would be well understood. It had to be shown that accidents didn't happen to "the other fellow" alone, under our company setup. Whenever one man was injured, the participants in the fund all suffered a loss.

In presenting the safety program, these facts were brought home to the employees and it proved to be a most convincing form of appeal for cooperation. Such an appeal, however, had to be specific and concrete. It was shown to them that as the National Safety Council and the American Association of Oil Well Drilling Contractors had determined, the cash losses are only part of the cost of accidents. The indirect costs are four times that, and in our business a great deal of hole has to be dug virtually "for free" to make up for such losses.

This part of the Safety Program, coordinated with the direct action of the drillers and the toolpushers in overseeing and enforcing safety measures, any violations of which they must report in case of an accident, created a strong influence toward keeping all the men aware of the danger and the economic waste of accidents. Finally the program of education in safety measures which is studied and discussed at the monthly meetings of pushers and drillers, not only tends to keep these men alert to the needs for safety measures, but it insures a direct appeal to the men in the small groups which make up the crews, where the information can be passed on effectively.

The Results

In the first three months of the program, accidents in our operations were reduced 40 per cent, a remarkable evidence of what could be done when the cooperation of personnel was obtained by education and an appeal to self-interest as well as good sense. This high percentage was not maintained, however, in the months that followed, indicating perhaps more strongly that the earlier showing was the result primarily of efforts on the part of the employees to cooperate with a new plan. It soon rose again as knowledge of our aims became more widespread, regaining the lost ground to raise the average reduction to 40 per cent for the eight month period. We feel that the results have been gratifying and we shall continue with the program because it not only works toward the safety of employees, but it creates new souces of profit through the reduction of the economic waste that goes with accidents. *

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ROCK FAILURE IN PERCUSSION†

Some results of Drilling Research Incorporated investigations in the field of non-conventional oil well drilling methods

JOHN V. PENNINGTON

Abstract

Drilling Research, Inc., has been engaged in the evaluation of methods of sinking deep holes in the earth by non-conventional means. One phase of the investigation has been a study of the fundamentals of rock fracture under percussion. This research is still in progress, but results achieved and conclusions reached so far are given in this paper.

The amount of energy available at the bottom of the hole in conventional drilling is limited, and the point is made that faster drilling will depend largely upon a substantial increase in such energy. One approach to this goal is by the transmission of electrical power to the bottom of the hole, and the use of primarily percussive devices on the rock.

The relation of the energy, velocity, momentum, etc., of the percussive blow to the amount of rock drilled was studied by observing single-impact blows on the rock and successions of such blows. Illustrative of the conclusions reached is the fact that, within the range of experiment to date, the amount of rock drilled depends upon the energy of the blow and not the velocity. On completion of the investigation, a more detailed report will be made available.

The Author

John V. Pennington is technical director of Drilling Research, Inc., which was organized in 1949. He was graduated from Stevens Institute of Technology in 1922 and Rice Institute with a PhD in 1933. From 1922 1923 he was employed as an engineer by Standard Oil of New Jersey, and for the next four years was an engineer for Public Service Production Company. He taught mechanical engineering at Rice from 1927 to 1933, when he joined Reed Roller Bit Company as research director. Leaving that company in 1945, he became an engineering consultant for the next three years. In 1948 he served as associate director of Southwest Research Institute.

Introduction

IN recent years, there has been a marked increase of interest in the adaption of percussive drilling principles to the drilling of deep holes in hard or medium-hard formations. This interest has been largely manifested in the development of bottom-hole hammer or vibration mechanisms, at least five of which are being field-tested at the present time. It seems quite probable that this development would be enhanced by a better understanding of the nature of rock disintegration under impact and of the optimum conditions for the utilization of energy available at the bottom of the hole in impact or percussion drilling.

For several years a group consisting of a number of oil companies and drilling contractors and a supplier has sponsored a research program, the purpose of which has been to determine whether or not some economical method of sinking deep holes by other than conventional means can be found. In an earlier paper, there was presented a classification of processes that might conceivably be employed for this purpose. These included mechanical, hydraulic, thermal, and chemical methods. After a considerable period of analysis and experiment, it has become apparent that all methods relying on hydraulic, thermal, explosive, or chemical means for disintegration of hard rock must fail for one reason or another at depths far short of those at which drilling costs and the need for a more economical process becomes really pressing.

Thus shallow holes might be drilled with speed and economy with an electric arc, with rocket exhaust, or with abrasive jets; whereas at greater depths the economy is defeated as a result of high back-pressure and frequent round-tripping. The conclusion has been reached, therefore, that any deep-hole drilling method, whether surface-driven or bottom-hole-driven, and whether mechanically, hydraulically, or electrically powered, must depend upon a mechanical attack on the rock to be economically successful.

Bottom-hole rock (the term "rock" being broadly employed to include hard shale, etc.) can be attacked mechanically (1) by vertical, crushing or impact forces, (2) by horizontal, shearing, abrading or gouging forces, or (3) by combinations of these. Typical of the first is the cable-tool, of the second the rotary drag bit, and of the third the rotary rock bit.

Faster drilling rates are continually being achieved in conventional drilling by the development of better bits, and by more efficient use of hydraulic jets. This means that the power available at the bottom of the hole is being used more effectively. In conventional rotary drilling, however, only a small amount of mechanical power can be made available at the rock for drilling. The power is completely determined by the revolutions per minute of the bit and by the resistive torque at the rock face. Both of these factors are seriously circumscribed by considerations of wear and maintenance, so that a saturation point, determined by the available energy, is rapidly being approached in the improvement of drilling rates with conventional tools.

What can be achieved with higher power levels is seen in the air-hammer, quarry-type drill. With 12 hp available at a 2-in. bit, Vermont granite is drilled at the rate of 2 ft per minute. Even discounting the fact that granite is somewhat brittle and the fact that drilling rates are usually higher in air than in mud, such a drilling rate, together with equally impressive rates in hard limestone, constitutes a real challenge to

*Presented to a group session of the Division of Production during the 33rd annual meeting of the American Petroleum Institute, in the Conrad Hilton Hotel, Chicago, Illinois, November 11, 1953.

the engineer of deep-hole drilling.

Thus, the further conclusion has been reached that significant improvement in drilling rates can be brought about only by making more power available at the bottom of the hole and using it percusively, at least in part. The limitations on transmission of greater power by drill-pipe rotation are well known. Development of percussive equipment depending upon increasing the supply of hydraulic energy is in the capable hands of a number of companies, and is going ahead with marked success, particularly in several special applications. There remains the possibility of transmitting down hole high levels of electric power (of the order of 200 hp), which might be used to actuate either rotary or percussive devices, driven by motors, magnetostrictive or piezoelectric transducers, variable-reluctance or tractive magnet mechanisms, etc. It was felt by the group sponsoring the research program previously referred to that the industry could best be served by a study of drilling processes and apparatus utilizing a relatively high amount of electrical energy, and capable of delivering percussive blows to the formation in a frequency range extending above that which can be obtained with mechanical or hydraulic devices.

A transmission line consisting of drill pipe with integral electric conductors was developed, and one type of transducer was selected for development that is capable of delivering up to say 1000 percussive blows per second, a range far exceeding the possibilities of mechanical or hydraulic devices. That any economic advantage exists with frequencies above 300 blows per second (18,000 per minute) is, however, very doubtful.

It is not the purpose of this paper to discuss the drilling mechanisms developed by Drilling Research, Inc., but rather to report generally on research in progress having to do with the more fundamental aspects of rock failure under percussion, and, in particular, to describe an approach consisting of the study of what happens to the rock under the impact of single blows. So many variables are involved in specifying a rock, so many more in describing a single blow, and so many more in defining an actual drilling operation, including the revolutions per minute, the frequency of impact and the fluid characteristics, that without isolation of some of these, the direction in which improvement lies is very difficult to find. The study of rock failure under single controlled-impact blows, and successions of such blows, is being pursued for Drilling Research, Inc., by R. Simon at Battelle Memorial Institute and A. M. Freudenthal at Columbia University, and will be published in greater detail at a later date.

Drop Tests

Drop Tester. This paper describes work done with simple apparatus. In fact, it stemmed from qualitative observations of the formation of chips with chisel and hammer. An instrument, called a "drop tester," was devised with appropriate instrumentation for quantitative observation of the same phenomena, and this was used for the first series of tests to be described herein. The drop tester, Fig. 1, consists of a rod carrying a cylindrical mass at the upper end and a bit at the lower end, the assembly being constrained for essentially frictionless vertical fall. Strain gages are applied close to the bit so that the force waveform can be recorded by an oscilloscope camera.

Another camera provides high speed motion pictures at the rate of about 3000 frames per second. The weight of the mass and the height of fall being known, the energy of impact, velocity, and momentum are easily calculated. The forces throughout the cycle are given by the force waveform obtained with the oscilloscope camera, and the motion pictures provide displacement-time and velocity-time curves as well as specific information as to the time and place of chip formation.

The drop tester can be indexed across the face of the rock to provide for successive impacts at predetermined distances from each other. The volume of rock removed by each blow can be determined by direct measurement or by filling the hole with Plasticine, which is easily removed and weighed.

This simple apparatus provides for an almost interminable number of interesting experiments, in which the controlled parameters of mass, height of fall, and indexing can be varied over the pertinent range, and various rocks and bits can be investigated.

It was first necessary to be assured that the dimensions and construction of the apparatus did not produce spurious effects by virtue of internal phenomena. In particular, it was determined that the length of the rod separating mass from the bit had no effect, up to 18 in. of length, on the force-time curve of impact. There is theoretical reason to believe that there might be such an effect resulting from the time required for a compression wave to travel up the rod and be reflected back to the bit. Because no substantial effect was observed, the falling assembly could be regarded as a lumped mass, making it then possible to use the force waveform as an acceleration-time curve for the bit edge.

For simplicity, the following remarks will be confined, except where otherwise stated, to the cases in which the rock is a rather uniform Indiana limestone and the bit is a chisel edge, ¾-in. long, with a .03-in. wide flat end and parallel vertical flanks.

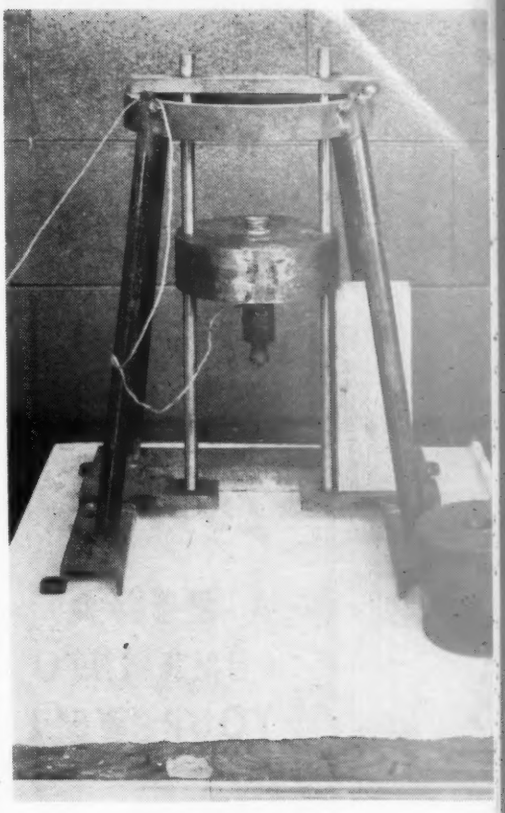
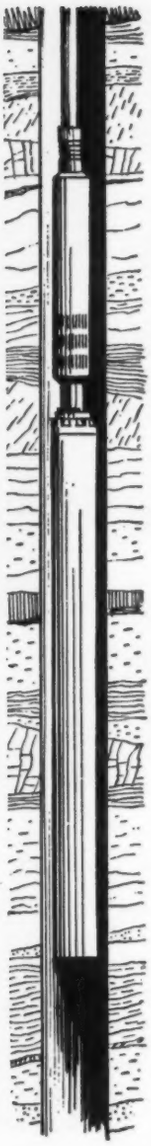


FIG. 1. Drop tester.

Force and Energy vs. Drilling Rate. Single blows were made using a 15-lb weight at various heights of drop. Fig. 2 shows four of the resulting curves of force at the bit vs. time, each curve being typical of a large number of observations. The first peak occurs at a force about 2000 lb regardless of the energy level of the drop. Then the force decreases and a second force peak results whose value increases with the energy level of the drop. For heights of drop below 9/16 in., the second peak is missing and the first peak varies with energy level. Above 6 in. of drop height, the second peak may also become constant in magnitude but sufficient data are not available to establish this point definitely.

The volume of rock removed in a single impact varies linearly with the height of drop, and therefore with energy of drop, the straight-line graph intersecting the energy axis at a point that may be called the treshhold energy, below which substantially no chips are formed.

A significant finding arose from a series of observations directed to the question as to the effect on the amount of rock destruction of changing the velocity of impact or the momentum of



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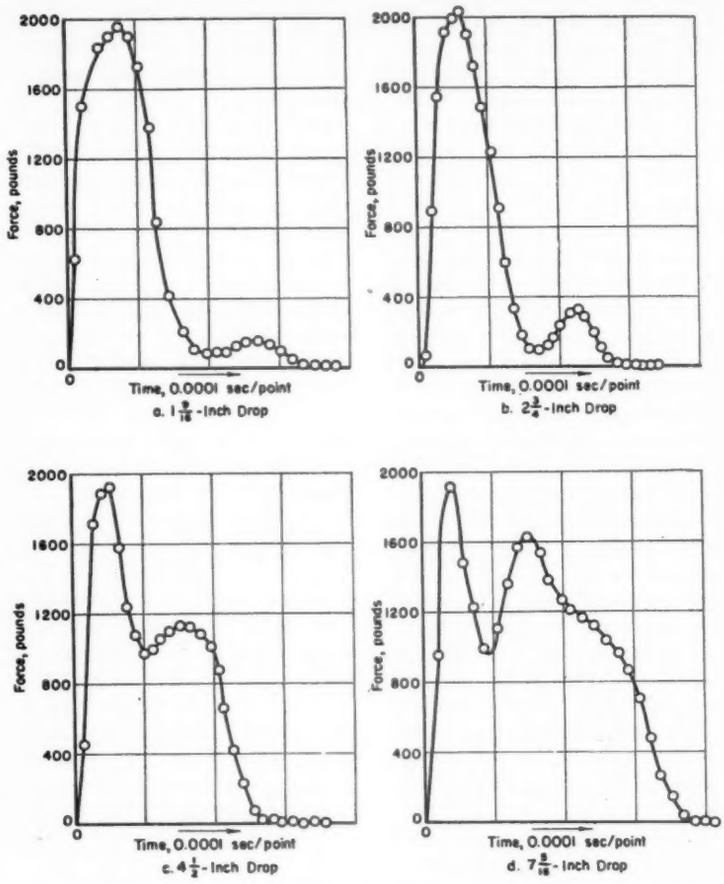

FIG. 2. Tracings of typical force waveforms for various heights of drop with 0.03-in. bit and weight of 15 lb for single blows on Indiana limestone.

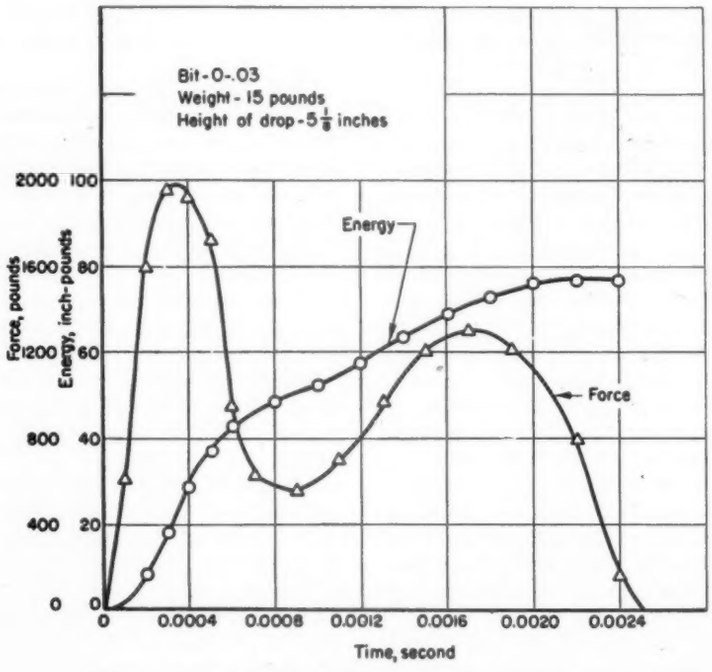

FIG. 3. Superimposed force — time and energy — time waveforms for a single blow on Indiana limestone.

the blow at a given energy level. The results showed, for the range of velocities and energies considered, that the amount of rock removed is dependent upon the energy alone. The velocity variation amounted to only 24 per cent; consequently, further tests will be needed to determine whether or not the preceding statement is broadly valid.

The dissipation of energy during an impact blow can be determined by integration of force wave forms, such as those shown in Fig. 2. Knowing the weight of the falling mass, the force scale can be replaced by an acceleration scale, as mentioned previously; and, by integration, the velocity can be found for all values of time. The energy dissipated up to a given time is then the time-integral of the product of velocity and force. When this is carried to the time when the velocity is zero (i.e., the time of deepest penetration and just prior to rebound), the total energy should approximate the potential energy of the mass before its fall, and it does so very closely. The energy found by integration to the time when the **force** is zero is less, by the energy of rebound, than the total energy, as expected. Study of the way in which energy is dissipated over the entire impact cycle is of interest in determining the most effective means for its utilization in disintegrating the rock.

In Fig. 3, the energy consumed up to any given time is shown superimposed on the force waveform for the 5⅛-in. drop shown in Fig. 2. It is seen that approximately half the energy is consumed during the first force pulse for this height of drop. In general, all the energy is used in the first pulse up to a certain height of drop. Above this height, the energy so used is a constant, the excess energy going into the second pulse. Now, the high-speed motion pictures, to the extent that they have been taken so far, show that the spectacular removal of large chips takes place during the first pulse.

The fact that the total amount of rock removed is linearly related to the energy of impact, however, and the fact that the energy dissipated in the first pulse assumes a constant value, suggests the simple hypothesis that the amount of rock removed per unit of energy for the first force peak may be the same as for the second, during which, generally speaking, smaller chips and powder are formed. It must be remembered that these remarks apply to a certain type of chisel edge and a certain rock. Other combinations of bit and rock may show more effective use of energy in the first pulse than in the second. More data are needed on this point. The approach to the problem, however, is thought to be clearly exhibited by the foregoing analysis.

Curves of displacement vs. time can

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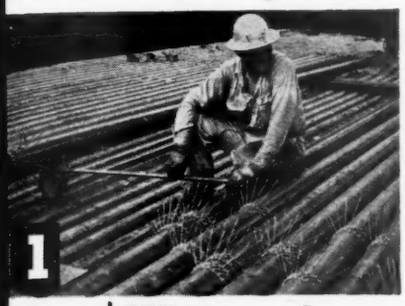

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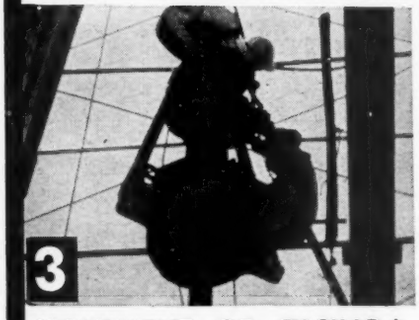

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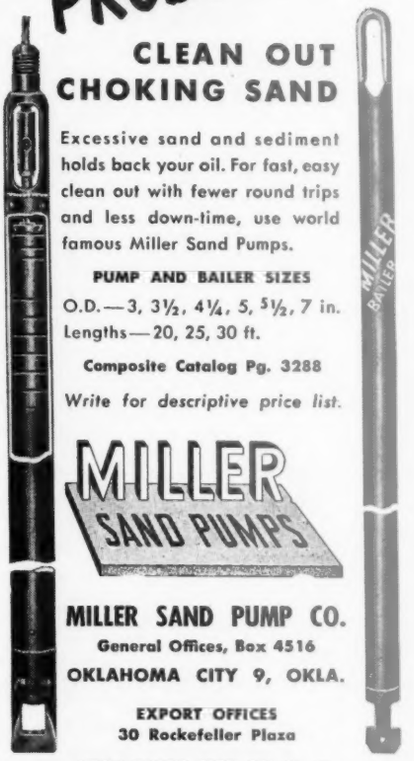

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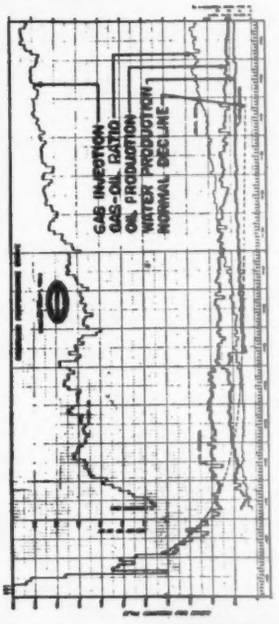

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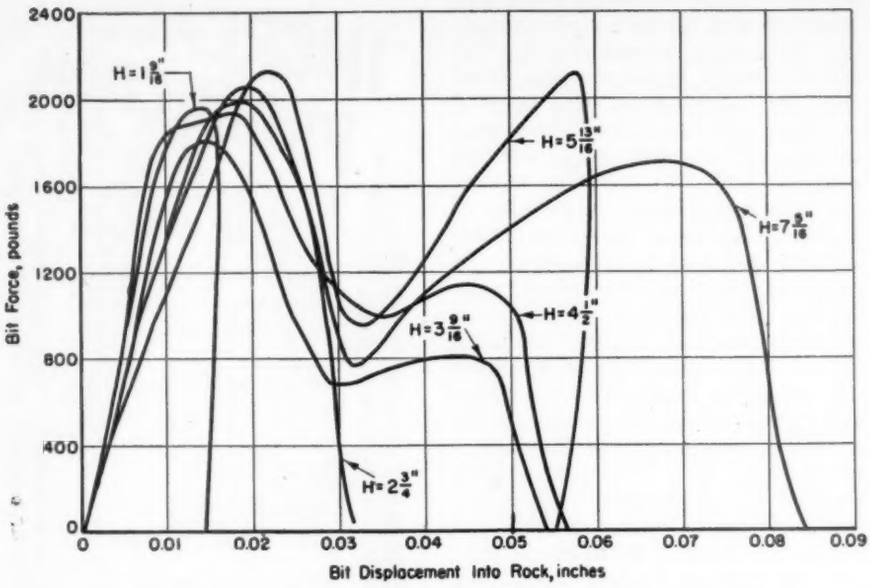

FIG. 4. Bit force as a function of displacement of bit into rock for several heights of drop for single blows with 0.03-in. bit on Indiana limestone.

be obtained in two ways, viz., from integration of the velocity waveforms and from the motion pictures. The two are in close agreement. These curves lead to nothing of particular interest in themselves, but provide a basis for developing force vs. displacement curves, about which something will be said.

Fig. 4 shows force-displacement curves for several different heights of drop. It has long been desirable to obtain such experimental curves for impact blows, but apparently this work represents the first successful effort in that direction. The story of an impact blow is significantly portrayed on these curves. The general trend of the force-displacement curve is the same as that of the force-time curve, but the former, as shown in Fig. 4, displays a substantial coincidence during the first pulse for all energies above the threshhold level. Thus, for all such energies, the impact produces the same force variation over the same depth of penetration for the first pulse, during which the larger chips are ejected. It is as though the falling chisel broke through a shell of given thickness and then, depending on the height of fall, resumed its penetration into a lower layer to a depth depending on the remaining energy.

The initial pulse of one of the force-time curves is shown in Fig. 5, with an expanded time scale. On close examination it is seen that it consists of four distinct regions. The region O-A has a slowly rising slope and corresponds to fracture and crushing of small irregularities on the surface of the rock. The force of the bit is thereafter transmitted through a thin layer of powered rock. The region A-B has a constant, high slope corresponding to elastic deformation of the rock, together with some subsurface damage. If the energy of impact is insufficient to raise the force of the blow above B, a considerable fraction of the energy returns in rebound or bounce of the bit, leaving merely a surface mark as visible evidence of the blow.

At point B the crushing strength of the rock has been reached. In the region B-C, a narrow portion of the rock is crushed and compacted, forming a wedge of compacted material directly under the flat of the bit. Through this wedge the increasing force is transmitted to the rock on each side, where elastic energy is being stored and strain trajectories are being developed. When the force reaches its peak at C the rupture strength of the surrounding rock has been reached and chips are formed by failure along the curved, almost horizontal trajectories of principal shear. As the chips break out, the central wedge, having lost its support, crumbles. As a result, in the region beyond C the force rapidly drops in value until the bit again contacts solid rock. The amount of chip-removing circulation determines the extent to which the powered wedge under the bit edge damps the continued progress of the bit, and the effectiveness of the second pulse.

The amount of rock chipped out in a single-impact blow is of interest in the drilling process, but so also is the amount of subsurface damage. The latter represents useful expenditure of energy that will pay dividends as succeeding blows are struck. One way of

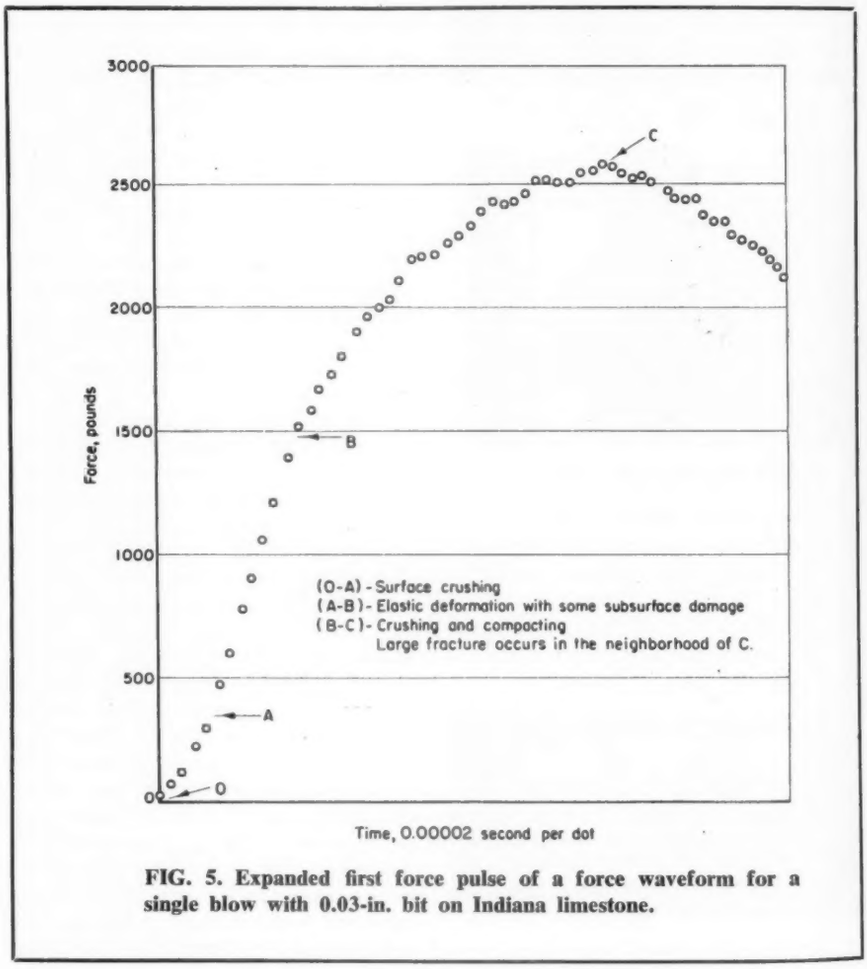

FIG. 5. Expanded first force pulse of a force waveform for a single blow with 0.03-in. bit on Indiana limestone.

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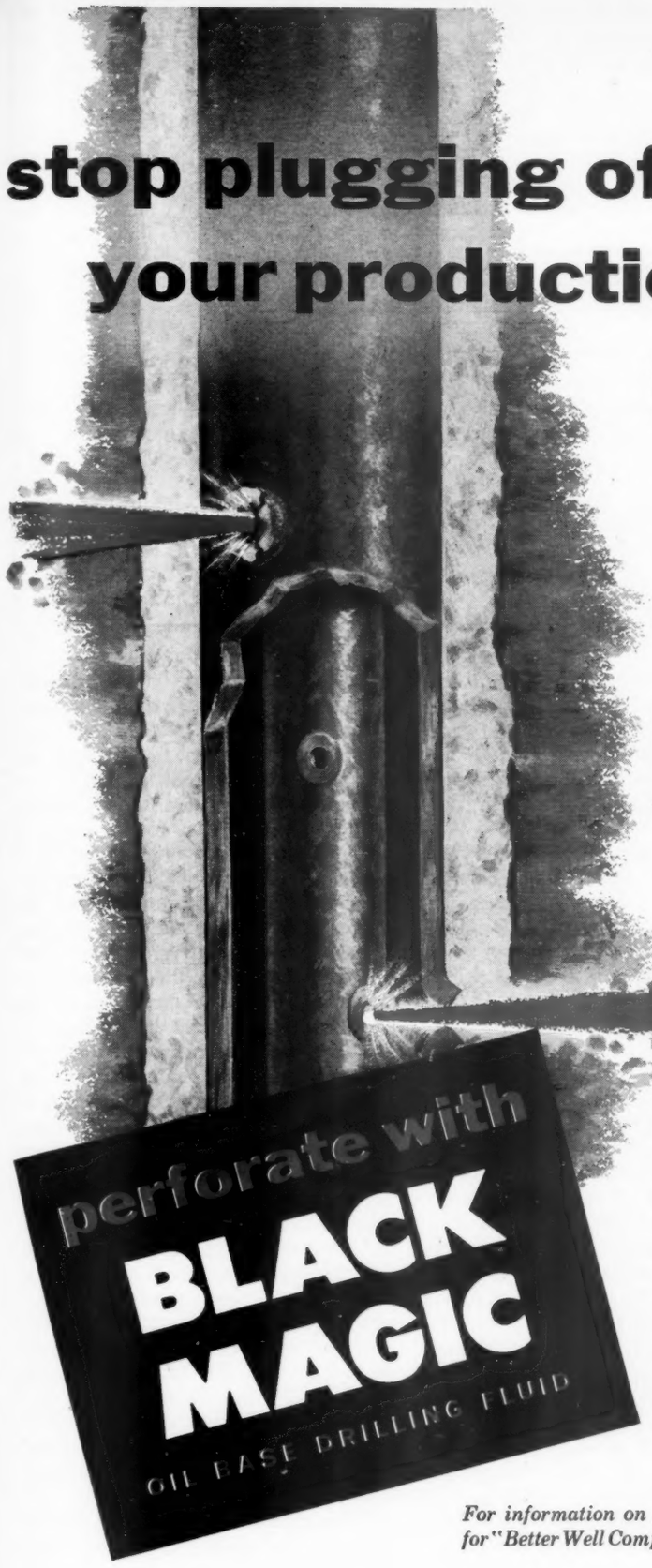

Experimental tests backed up by actual field data prove conclusively that when perforating is performed in the presence of clay-water muds, mud particles are forced into the newly opened shot-holes where they are compacted by pressure and baked by excessive heat to form a solid plug that immediately seals the hole.

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>
> (*Effectiveness of Gun Perforating, Journal of Petroleum Technology, January, 1954.*)

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getting at least a qualitative view of the extent of such subsurface damage caused by a single blow, is to strike the blow in question near the edge of a block of rock but not close enough to break the edge off. A second blow, heavy enough to knock the edge off the rock, is then struck right alongside of the first at the same distance in from the edge of the rock.

Referring now to the first blow, which is the one under examination, if the height of fall was less than ½ in., the line of fracture caused by the heavy blow never followed the line of the first impact blow. For heights of drop from ½ to ¾ in., the fracture always followed this line showing that some damage had been done. The fractured surface under the line of the first blow, however, showed that no crushing had occurred, inasmuch as no powder was present. The damage presumably consisted of cracks in the grain boundaries. For heights of drop above ¾ in. the fracture again followed the line of the first blow and crushing was evident under the flat of the bit edge. Often the crushed material could be removed from the new surface in the form of a compacted wedge that could be crumbled between the finger.

Other Bits and Rocks. The angle between the flanks of the chisel-edged bit has considerable effect on the drilling characteristics of the bit. In all of the foregoing work the flank angle was zero, i. e., the flanking faces were paralled. In a series of tests employing flank angles of 45, 90, and 135 deg, it was found that, for a given height of drop, the peak force developed at impact varied directly as the square root of the tangent of half the flank angle; and the amount of rock removed varied inversely as the tangent of half the flank angle.

In another series of tests the width of the flat bottom of the chisel edge was varied, with the expected results that the wider flats drilled more slowly. From the evidence obtained thus far, however, it appears that small flank angles are much more important for the achievement of rapid drilling rates than the avoidance of flats, or dullness, on the bit edges, provided that the energy of the blow is above the threshhold value required for the initiation of rock fracture. Experience with the drop-tester strongly suggests that the optimum bit edge for percussion drilling may be one with zero or a small flank angle, with just enough width for the strength required. Furthermore, the drilling characteristics of such a bit should not change perceptibly until the edge is completely worn down.

Tests were made on rocks other than Indiana limestone. So far, data are insufficient except for Columbus limestone, which shows phenomena very similar to those obtained with Indiana limestone, but with drilling rates approximately one-fourth those in the latter.

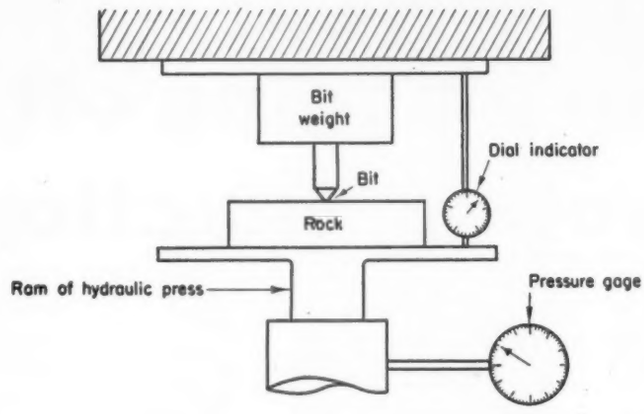

FIG. 6. Schematic diagram of static loading tester, bit-rock pressure supplied by a Carver hydraulic press.

Repeated Blows. Next in interest, after the single impact blow, is the effect of repeated blows on the same spot. This occurs in percussive drilling when a cone or roller bit is used, and also, in effect, with very small indexing angles when star bits are used. When successive blows are struck by the drop-tester on the same spot, the debris being blown out with air after each impact, the second blow removes considerably more rock than the first, and the third still more. Thereafter, the amount removed decreases gradually until it is negligible to, say, the sixteenth blow. This indicates that the first blow has done some damage to the rock, not revealed by the amount of rock removed. Close inspection shows that some crushed rock was not removed by the air blast, although the blast was believed to be equivalent to good bottom-hole fluid circulation in its chip-removing efficiency. Another phenomenon may also be present—progressive fracture, for which some evidence was presented previously.

A few investigators have spoken of the *fatigue* of rock in percussive drilling, and the phenomena under consideration here may be so labelled if one chooses. Measurable failure occurs after several cycles of stress. A series of conventional fatigue tests on specimens of limestone and granite, both in compression and in torsion, failed to reveal, however, after thousands of cycles of stress, any endurance limit appreciably below the static strengths of the rocks. It is believed that failure will not occur at stresses below the rock strength and, therefore, that fatigue as generally understood is not present.

Indexed Blows. It now becomes of interest to inquire as to the effect of spacing the impact blows from each other in a direction perpendicular to the bit edge by an amount called the "indexing distance." If the indexing distance is sufficiently great, each blow will, of course, have the same effect as a single blow. Statistically speaking, however, there is a critical distance, dependent upon the energy of the blow, such that when the second, or indexed, blow is struck, it knocks out more or less flat chips extending back to the previous crater. The amount of rock removed by a blow in this way can be of the order of three or four times the amount removed by a single blow with the same expenditure of energy. Indexing, therefore, appears to be of importance in the efficient use of the energy available for drilling, and gives significance to the ratio of frequency of percussion to rotation rate. Roughly speaking, greatest efficiency with a star-bit would be attained when it is rotated in such a way as to strike successive blows spaced apart at the periphery of the hole by a distance equal to the critical indexing distance. With a cone or roller bit, the greatest efficiency should be obtained with a distance between teeth approximating the critical distance.

The foregoing work was corroborated in a series of tests in which the single chisel-edged bit was rotated after each impact blow by an amount referred to as the indexing angle. It was found for each rock that there was a

critical indexing angle, at which the highest drilling rate was obtained, the rate falling off for lesser or greater indexing angles.

Static Loading Tests

Further information leading toward a working theory of percussion drilling was obtained in static loading tests. The same rock and bit were set up in a hydraulic press with provision for measurement of force and displacement, as shown in Fig. 6. The crater formed in the rock resembled closely those formed during the drop tests. The chips, however, remained in place instead of flying out as in the drop tests. The force-displacement curve was closely similar to that obtained in the drop tests, and the first major fracture occurred at the same force level. Again, therefore, it appears that the amount of rock removed is independent of the rate of application of the load.

In one respect the static loading tests gave results that were not in line with some of the drop-test results mentioned previously. In the static tests it appeared that the energy required to fracture out a given amount of rock was considerably less than for the drop tests. For the static tests the loading was usually increased in each test until major chipping occurred, whereupon the test was terminated. On the other hand, for the drop tests, a given fixed amount of energy, as determined by the potential energy of the weight, was introduced into the system for each test.

If this amount were more than enough to produce major chipping, the remainder would be essentially wasted unless it happened to be enough to produce a second major chipping action. If the energy were insufficient to produce the first major chipping, it would be largely wasted. In practice it would not be entirely wasted, because the rock may be left in a weakened condition so as to contribute to the effectiveness of subsequent blows. Thus, if a practical means could be devised for removing the lead each time as soon as chipping occurred, much more efficient drilling would result.

Drillability. All of the foregoing is illustrative of the way in which percussion drilling can be studied blow by blow with the variables under complete control and with the problem of instrumentation and measurement tremendously simplified. The technique can be applied to the investigation of fracture of all oil-country rocks — soft, hard, friable, and tough. It can be used to study variations of bit-tooth forms and of assemblages of teeth into a complete bit. The effect of the presence of water and other drilling fluids on the drillability of the rock can be determined. The motion of the falling weight can be constrained to simulate simple harmonic or other velocity cycles to measure the effect of the motional constraints of actual drilling tools, etc.

A measure of drillability is suggested by the close correspondence of the static to the impact tests. It is well known that the drillability of rocks by conventional tools cannot be correlated with any of the standard methods of measuring hardness, nor with the crushing strength, grinding rate, or other parameters used for ranking materials.

Insofar as percussion drilling and possibly rock-bit drilling are concerned, however, it appears that drillability is a simple function of the peak force developed in the first force pulse and of the amount of crater produced when a chisel-edge is pressed into the face of the rock in question. More data are required before this can be formulated with any degree of confidence.

Next in interest, after single and repeated impacts, comes the study of rapid successions of blows as in the actual process. The range of frequency studied was from 60 to 1400 cycles per second; and, in almost all instances, the rock was Columbus limestone. This limestone is made up of a grayish matrix with Moh's hardness of 3, containing irregularly sized and shaped white inclusions of Moh's hardness exceeding

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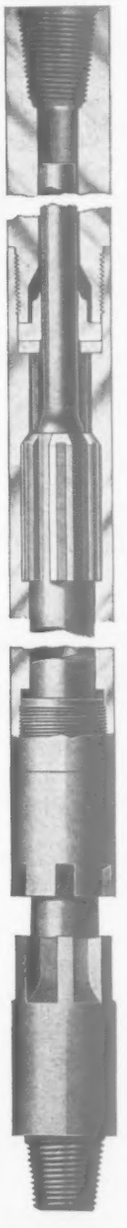

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4, and is somewhat fossiliferous.

Three types of apparatus were used: (1) a pressure chamber, containing the rock specimen, and mounted on an SF-4 Sonntag fatigue-testing machine operating at 60 cps; provision was made for transmitting the vibratory force to a bit at the specimen face, for rotation of the bit, and for a superimposed static load; (2) a larger-scale, horizontal vibratory drilling tool capable of driving bits up to 3 in. in diameter; and (3) a still larger-scale drilling assembly mounted vertically in a limestone quarry and capable of driving a 4⅝-in. bit. A fourth unit is under construction for down-hole drilling with bits up to 10 in. in diameter.

Comment on the results obtained will be confined at this time to those points that serve to round out the preceding discussion. When percussion is obtained by a vibrating tool, as distinct from a hammer-type of drill, the action may be of two types, depending upon the contact time of bit and rock during each cycle. If the static loading is sufficiently high, the force between bit and rock never drops to zero and we have 100 per cent contact time. If, on the other hand, the static force is less than the dynamic, the bit may actually leave the rock during a portion of each cycle and true percussion results.

It was found that no advantage was realized with a dynamic force considerably less than the static load. The dynamic force could be replaced with an equivalent static force by adding drill collar, and the same benefits would be derived. It was otherwise with fractional contact times. Fairly spectacular drilling rates could be obtained, with relatively low static, or drill-collar, loading, particularly when the rotation rate was sufficiently great as to give a favorable ratio of vibration frequency to table revolutions per minute, as mentioned previously in connection with the question of indexing.

Drilling rates increased slowly with frequency of percussion. Other factors, however, operate against proceeding to very high frequencies. One is the line loss in transmitting high-frequency electric power down-hole. Another is the high rotation rate that is required with higher frequencies to give effective indexing. At present, an optimum point in frequency range seems to be between 200 and 300 cycles per second. This might still further be modified by such considerations as the availability of 60-cycle current and equipment, which could be used to produce 60 or 120 cycles per second percussion.

Work in the quarry and laboratory indicates that, for drilling at such frequencies, new types of bits may be required. So far as drilling rate is concerned, noteworthy advances have been made. However, bit life is of equal importance and will be studied with the down-hole equipment.

The foregoing experimental investigation, together with a theoretical investigation of the resistance of rocks under conditions of percussion drilling, provides a basis for:

1. **Determining measurable mechanical properties in terms of which the resistance of rock to percussion drilling can be expressed.**
2. **Determining the optimal conditions of operation of a percussion-drilling device.**
3. **Comparing such operation with that of the best conventional equipment for assessment of potentialities of percussion drilling.**

The approach is that of the slower, but perhaps surer, process of building on more fundamental knowledge, as distinct from the alternative approach consisting of making the tool and giving it a field trial. There is no argument against the latter approach, which has a long, successful history, other than the fact that the complexity of the problem in percussion drilling makes the trial-and-error method one of doubtful value unless by chance the right combination of elements is achieved early in the game. * * *

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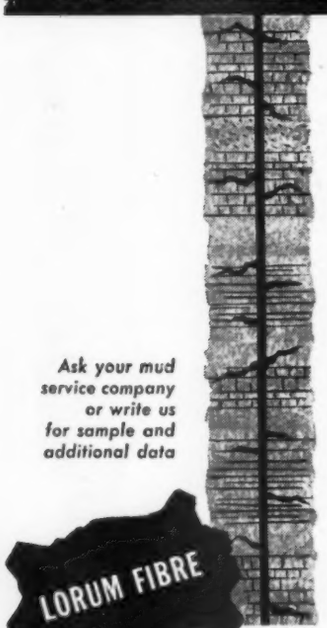

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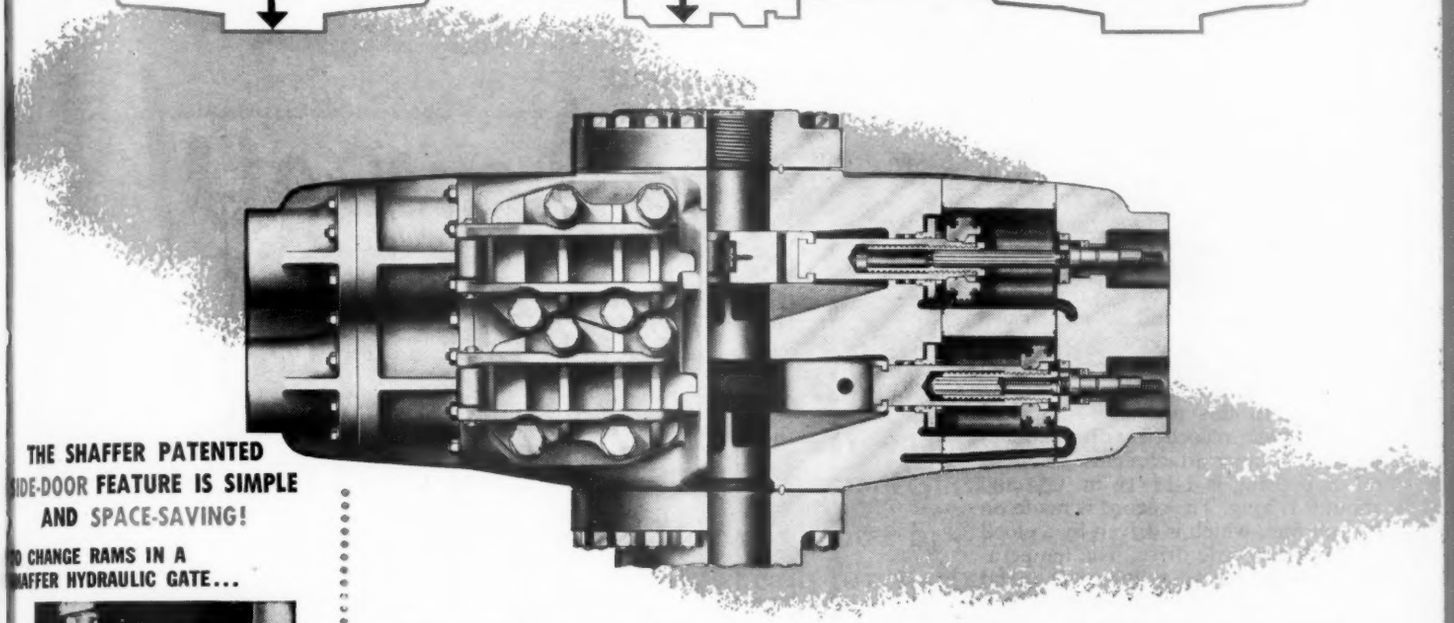

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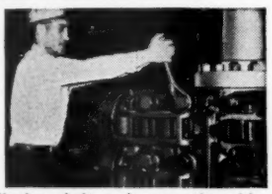

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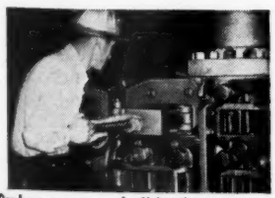

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Interpretation of

Thermometric and Spinner Surveys

Use of combined tools in producing wells permit more positive conclusion from data received on tests

CLARENCE R. DALE

THE combined use of thermometric and spinner surveys in producing wells makes the interpretation of the results obtained more conclusive than where single surveys are made.

Surveys illustrated in this article show the advantage of the use of the two measurements and in some cases a satisfactory interpretation could not be made without both surveys.

The instrument used for the surveys described in this article is the Dale photographic recorder with temperature and spinner attachments. The barrel or housing is 1-11/16 in. OD and about 9 ft long. The record is made on 16 mm film, which is driven by a clock controlled electric drive. The temperature attachment is a helical bi-metal element that varies a light beam, which is photographed continuously on the moving film. The spinner attachment employs a helical vaned rotor with the shaft mounted on jewel bearings. The rotor and shaft assembly is the only moving part exposed to the well fluid. Revolutions of the rotor are picked up by a miniature magnetic switch in a fluid tight housing that is mounted parallel to a brass and iron disc on the rotor shaft. The switch is actuated by the iron portion of the disc and the contact is broken when the brass part of the disc revolves past the magnet. The RPM of the rotor is recorded on the moving film by a combination electrical and optical system. The record is a series of dashes on the film; each dash and space representing 20 revolutions of the rotor. Fluid traps that are held in a collapsed position going into the well direct the fluid through the rotor for both upward and downward flow surveys.

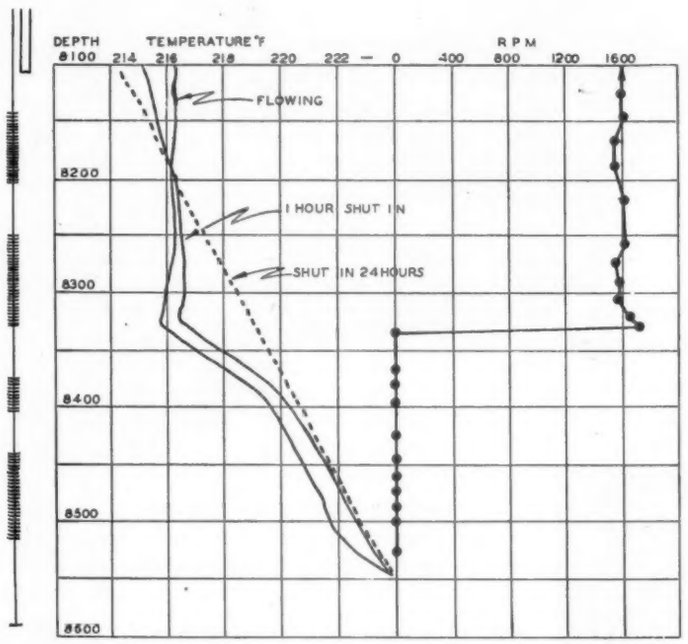

FIG. 1. PRODUCTION from only the lower portion of one set of perforations.

In flowing wells the instrument is run through the tubing, under pressure, on a measuring line and is lubricated into the well with the same procedure used in running a pressure bomb. Surveys in pumping wells are made by running the instrument in the annulus between the tubing and casing, and can be made under pressure with a lubricator. Temperature surveys are run at a controlled speed by a hydraulic feed on the hoist and a continuous record of the temperature is made. Spinner surveys are made by stopping the instrument at stations where the RPM of the rotor is recorded at each station. Spinner surveys have been made successfully on wells producing less than 30 bbl per day oil in 6⅝-in. liners. Lower fluid velocities can be recorded in oil than in water, but water injection wells with injection rates as low as 60 bbl per day have been surveyed with excellent results.

Fig. 1 shows a well with four sets of gun perforations through a cemented casing. The tubing is above the top set of perforations and the well production was 1,500,000 cu ft of gas and about 20 bbl of oil per day. The Spinner and Thermometric surveys indicate gas entry from the lower part of the second set of perforations between 8330 and 8335. On the flowing temperature survey convection and conduction have reduced the temperature of the fluid standing in the well below the gas entry to less than the formation temperature. The sharp change in gradient opposite the lower blank section on the flowing temperature survey indicates a heavier fluid, probably mud, is standing through this area. An interpretation of the temperature surveys could be made that there was a minor entry of gas from the perforations below 8500 ft but the spinner survey completes the picture, indicating the single source of gas. Repairs made on the well reduced the volume of gas to less than one-half

The Author

Clarence R. Dale entered the oil business with the Union Oil Company in 1920. In 1928 he began development of instruments and tools for use in the oil industry, including early surveying instruments. Among his developments is the photo-electric method of locating water entry in wells. He is now owner of the Dale Company and the instruments described in this article were developed by him.

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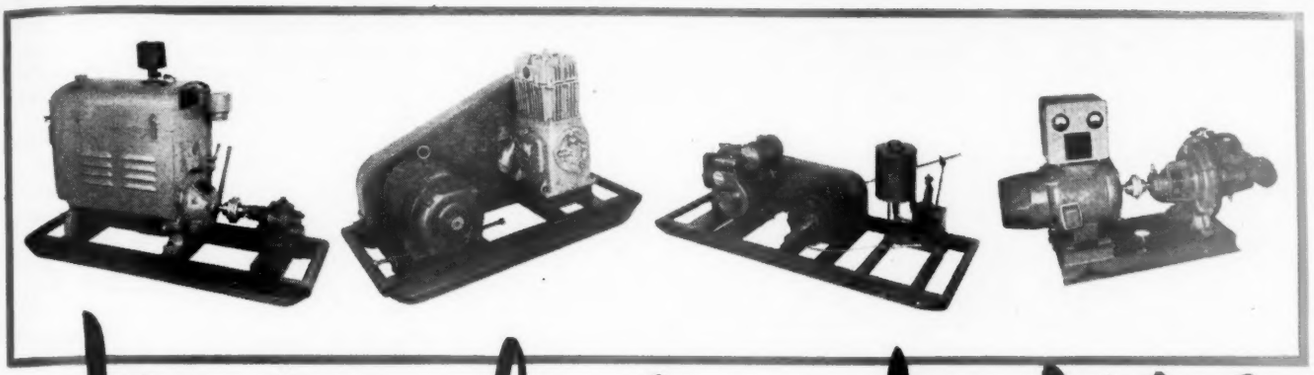

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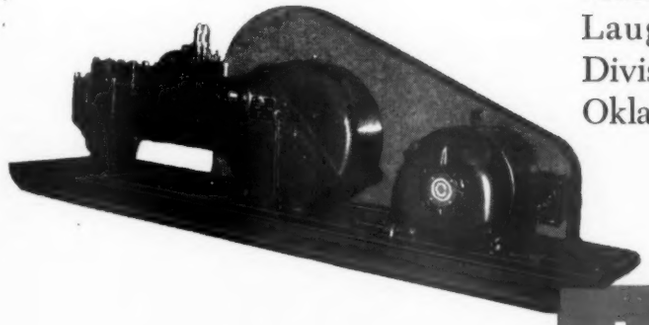

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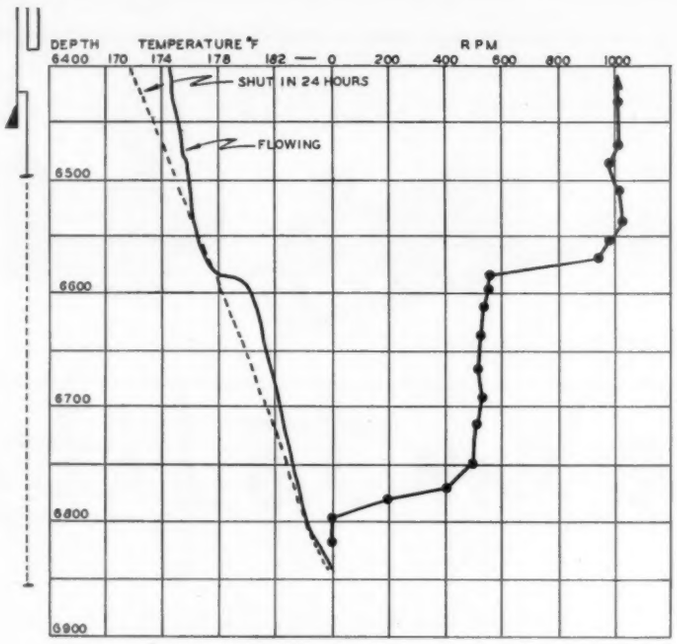

FIG. 2. Defining gas and oil entry.

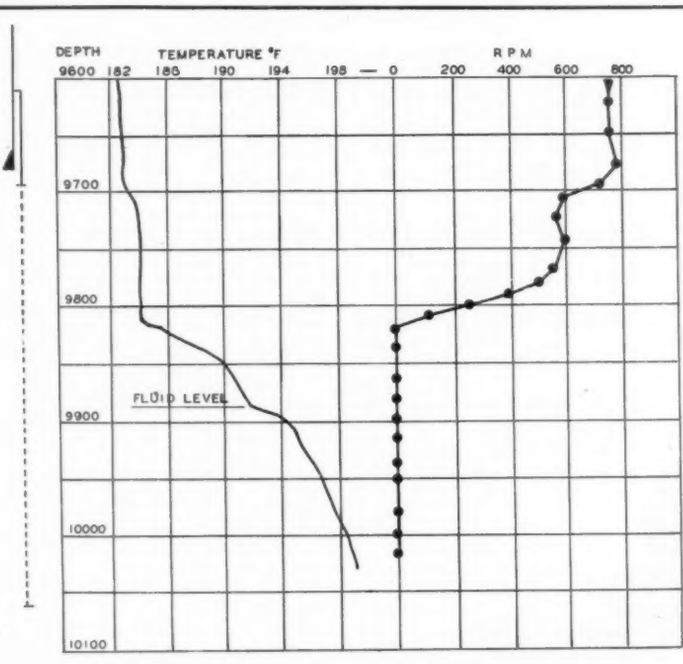

FIG. 3. Formations taking gas in gas injection well.

a million cubic feet, and increased the oil to over 100 bbl per day.

The well shown in Fig. 2 was producing 325 bbl per day oil with a 2000 gas/oil ratio. By the use of the spinner survey alone it would have been impossible to tell which increase in rpm was the gas entry. The temperature survey, by the drop in temperature, indicates that the increase in rpm on the spinner survey, from 6570 to 6580, is the gas entry. The flowing gradient from 6790 on the flowing temperature survey corresponds to the increase in rpm on the spinner survey from 6790 to 6750. Results of these surveys confirmed formation tests that had been made when the well was being drilled. In most cases where the gas and oil are being produced from different intervals, use of temperature and spinner surveys distinguish and indicate the entry points of both the gas and oil.

Great care must be exercised in making interpretations of temperature surveys in gas injection wells, where only the temperature survey is available. This is illustrated in the well Fig. 3. Approximately one and one-half million cubic feet per day was being injected in this well. With over 350 ft of zone open only about 75 ft of formation is taking gas. Some gas is entering the formation at the top of the perforations and the balance is going into the formation from 9765 to 9815. The temperature survey confirms the spinner survey with an anomally at the top of the perforations and an abrupt change in gradient at 9815, the lowest point that gas is entering the formation. Another change in temperature gradient occurs at 9890, the fluid level. Unless the fluid level was known to be at this point, it would be very easy to pick this change in gradient as a formation taking a part of the gas. In some gas injection wells, increases in volume of gas being injected increases the area of the formations taking gas, but in many cases the area taking gas does not change. In California, in the wells surveyed by the author, on an average only about one-fifth of the formations open to gas injection are taking gas.

In the water injection well, Fig. 4, approximately 600 bbl of water per day was being injected when the spinner survey was made. The temperature survey made while water was being injected, was at the same injection rate as that on the spinner run. The spinner survey and the temperature survey made while injecting both indicate that all the water is going into the second set of perforations. In water injection wells, where the water has been injected for a long period of time, shut in temperature surveys show anomilies in areas that may have been taking only negligible amounts of water. It is also possible that some of these anomalies occur opposite formations that are thoroughly saturated but not taking injected water.

The presence of mud standing in a well can hold back a substantial part of the production as indicated by the surveys made in Fig. 5. The spinner and temperature surveys made at the 300 bbl per day rate show that all of the production is entering the well from the top few feet of the second set of perforations. A pressure survey indicated mud standing in the well below the fluid entry. The well was flowing at a high rate for several hours and then put back on the same flow bean. The production had increases to 393 bbl per day. The spinner and temperature surveys made at the higher rate indicated that most of the second set of perforations were now contributing production. A pressure survey indicated that the top of the mud was at 6175, the lowest point that was contributing fluid. In 40 wells in 16 fields surveyed in California, the average fill-in of solid material, which was either sand or mud, was 61 ft. If light mud or emulsion, standing in the wells, was added to this figure, it would be much higher. It is not always the long producing intervals that have substantial fill-in as shown in the well in Fig. 5. Two wells in the 40 had more than 300 ft of fill-in, which was in one case

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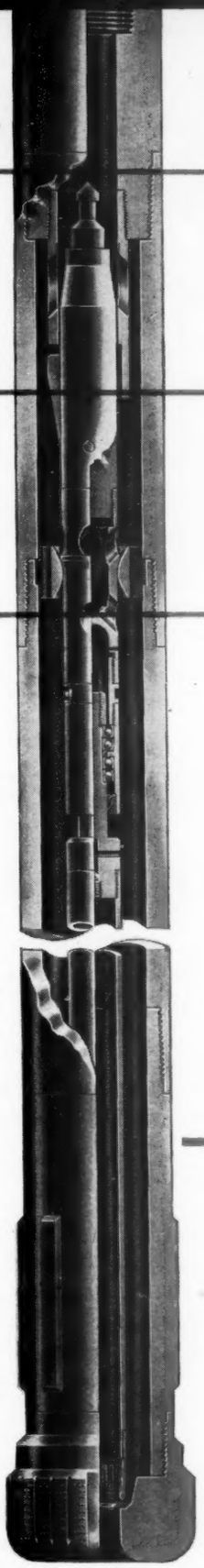

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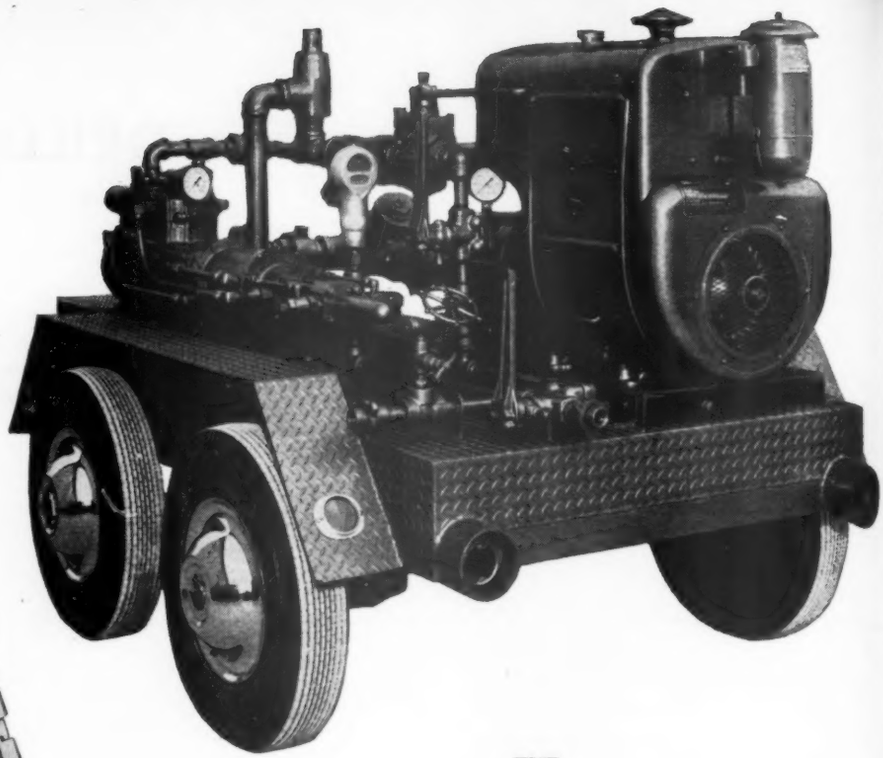

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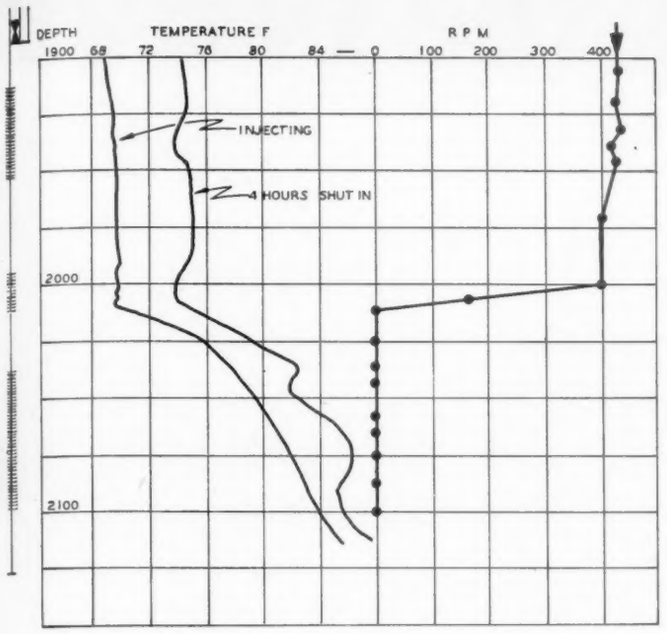

FIG. 4. LOCATION of entry point in water injecion well.

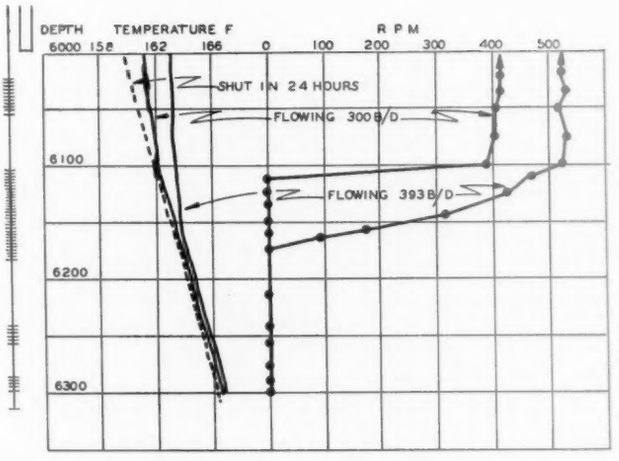

FIG. 5. LOWER portion of this well probably contains drill mud.

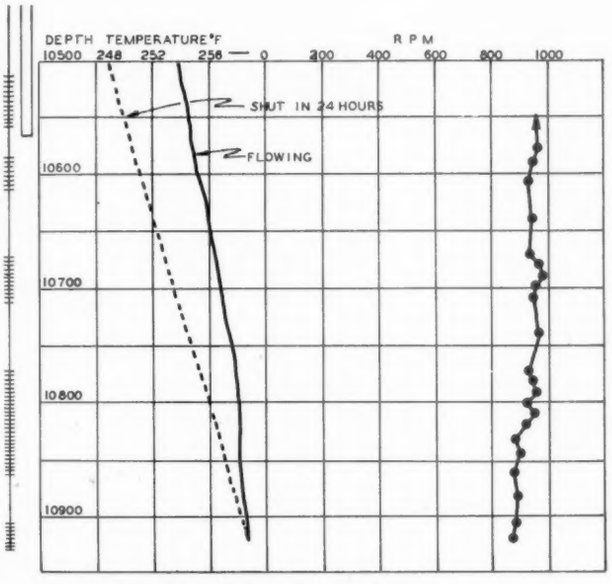

FIG. 6. EVIDENCE of fluid production from lower perforations only.

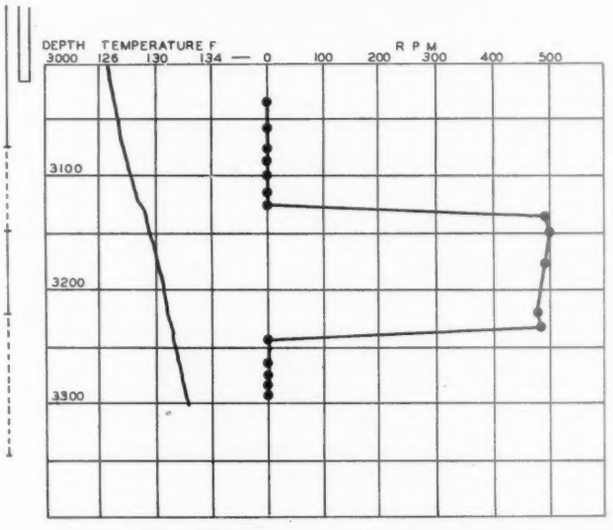

FIG. 7. LOCATION of fluid entry point in pumping well.

three-fourths of the perforated interval, and in the other almost half.

Spinner and temperature surveys can be used to locate water only when the production is all or nearly all water. Many times, however, spinner surveys are used to confirm water locating surveys. When water entry has been located, a spinner survey can be used to define the oil entry, providing the cut is not too high. The surveys, Fig. 6, were made when the well was flowing about 600 bbl per day with an 80 per cent cut. Temperature surveys indicate flow from the lowest set of perforations and the spinner survey shows all of the production was coming from these perforations. The well was plugged back to 10,875 ft and the upper four sets of perforations would not produce either water or oil. It was necessary to drill out the cement and reperforate the section below 10,900 ft, in order to get back the production that was lost and all of the production was recovered, including the water.

Where fluid or gas is migrating through a short interval in most cases the temperature survey has little value. The spinner survey gives a clear picture of the point of entry and point of loss of production. Most migration has been detected on shut-in spinner surveys, but in a few cases loss of fluid has been indicated on flowing surveys.

Fig. 7 is a shut-in annulus survey made on a pumping well indicating downward migration. The fluid is entering the well from 3125 to 3135, moving down and into the zone 3230 to 3240 ft. Several other wells surveyed in the same area with this well, and with similar completions, indicated migrations from the upper to lower zone. In one field where two zones were open, there was a known pressure difference of 200 psi between the zones, with the lower zone having the lowest pressure. Migration of gas was taking place between the zones and it was estimated that not less than 1,500,000 ft of gas per day was moving from the upper zone to the lower zone of this well.

The use of thermometric and spinner surveys together has made interpretation possible in a great many cases where, with a single survey, several different interpretations could be made. The equipment and the technique of operation is steadily being improved so that more and more information on the conditions in the producing well will be available to the engineer. * * *

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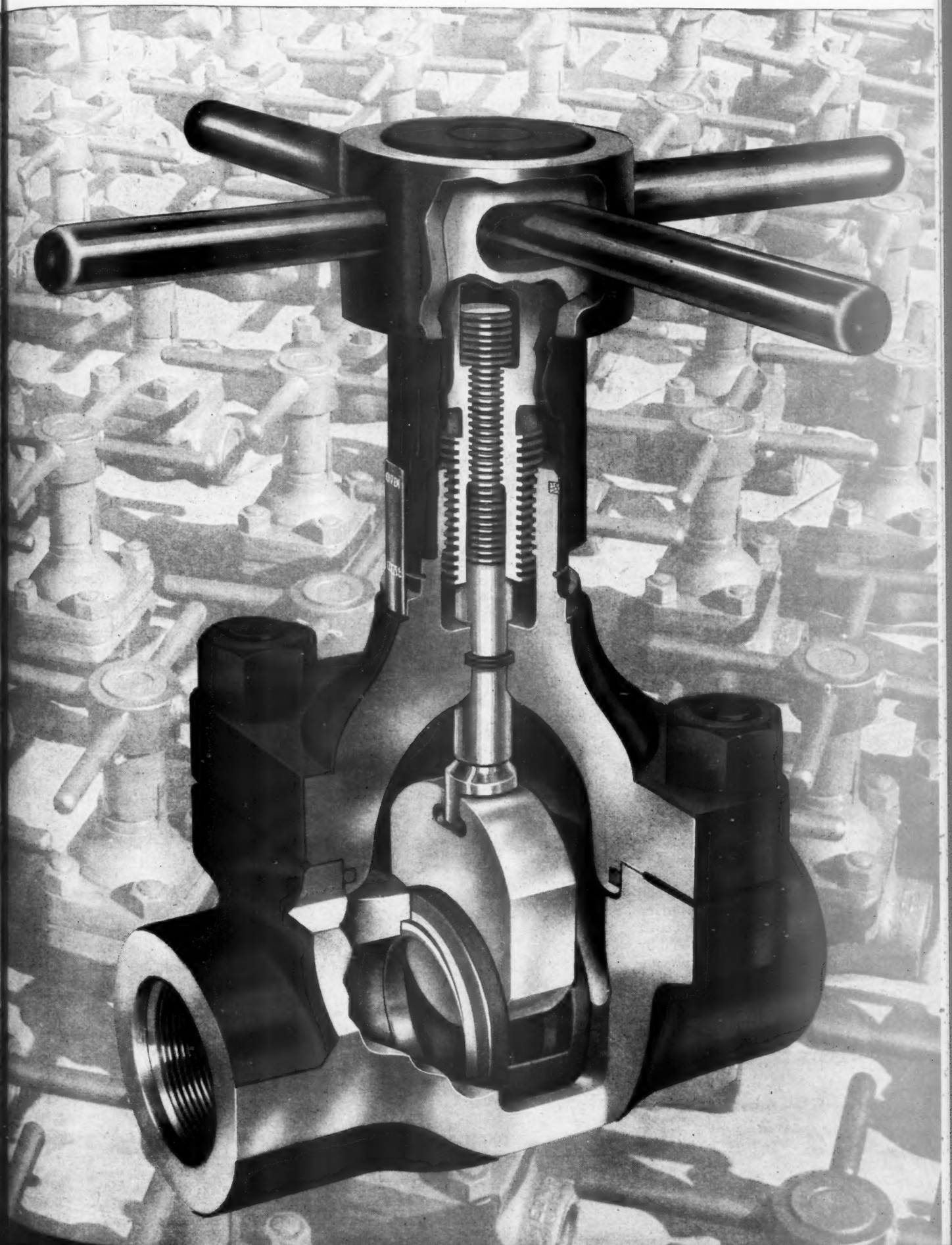

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South Louisiana Gas and Water Injection†

Pressure maintenance program in unitized operation decreases development cost, improves production efficiency, and conserves gas for future recovery

R. L. EVANS and A. E. BARRY*

DURING the past decade it has become almost commonplace in the industry to see oil and gas operators undertake extremely complex secondary recovery projects, requiring the investment of million of dollars, in their efforts to achieve maximum realization from their properties. The Hackberry pressure maintenance program is an operation of particular interest not only because it employs secondary recovery techniques to circumvent some of the problems inherent in salt dome development, but also because it differs from ordinary secondary recovery projects inasmuch as water and gas are injected to supplement the natural forces at work as opposed to injection after they have been exhausted.

The program contemplates coordinated water and gas injection, the two phases having been separately conceived and initiated in 1945 and 1950 respectively. Under proper regulation the program should realize: (1) efficient recovery of hydrocarbons in place; (2) effective depletion of the reservoirs in a reasonable time; (3) substantial savings in well investment; (4) elimination of waste and substantial increase in revenue from storage of gas that would otherwise be flared.

Hackberry Area

The Hackberry Dome is situated in the parish, or county, of Cameron in Southwestern Louisiana, approximately 15 miles from the Gulf of Mexico and 25 miles from the Texas-Louisiana boundary. Access is by all-weather road from the town of Sulphur and by water via Calcasieu Lake, which is connected with the Gulf of Mexico and the Intracoastal Canal. The terrain is predominantly flat marshland modified by scattered ponds, lakes, bayous, and canals.

The underlying structure is a piercement type salt dome, five to seven miles in cross section, its long axis trending east and west. (Fig. 1) The cap rises to within 2000 ft of the surface at either end of the dome, creating two features separately recognized as fields and designated as East and West Hackberry. Production operations date back to the 1920's but as in the case of most salt domes, exploration around the flanks progressed slowly. New productive areas have been encountered as recently as 1952 when development of deep Oligocene deposits on the West flank commenced. The area under discussion, the West Hackberry unit, lies on the northwest flank of the dome.

West Hackberry Unit. Production in the area contained in the unit was discovered in December, 1940 with the drilling of a well now designated as Unit Well No. 6 (Fig. 2) This and subsequent wells ultimately defined a productive area extending approximately 11,000 ft along strike and at its widest point, approximately 1250 ft down dip. The eastern limit of the accumulation is defined by a dry hole, drilled one location east of Unit Well 1, and the western limit by Unit Wells 16 and 22 in which the producing sands were diminished or missing as a result of faulting. The productive area as finally determined and included in the Unit embraces 232 acres.

The development program ultimately identified three main sands of Oligocene age designated Camerina "B" "C", and "D" zones in order of depth, as containing substantial deposits of oil. (Fig. 3) A higher sand, the Camerina "A", proved to be inconsequential. A deeper sand, the Kaough, is lenticular in nature and although it has warranted some updip development, its characteristics eliminate it from consideration in the program under discussion. As depicted on the schematic cross-section the sands are steep, having a dip of 60 deg. Rather than pinching out against the salt, they are truncated by an interruption interpreted as a low angle peripheral fault. This truncation, although somewhat irregular, appears to be relatively horizontal along the strike of the formations except in the eastern 500 ft where it dips downward to intersect the oil-water contacts of the sands and close the oil reservoirs.

The Camerina "D" sand is the most important of the three main reservoirs, having potentialities greater than the

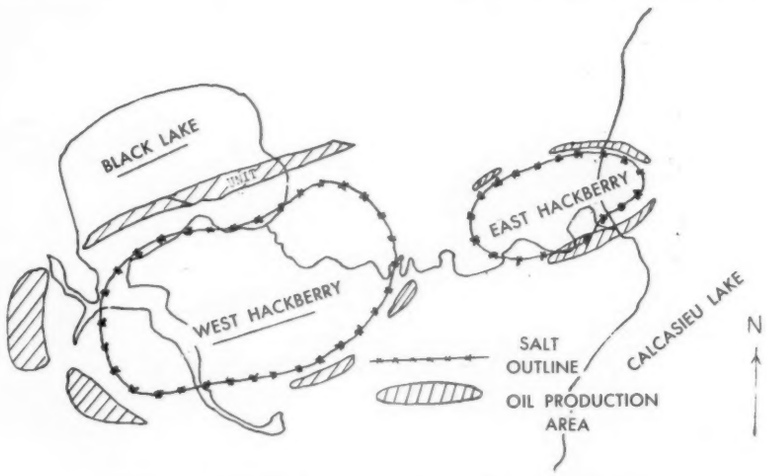

FIG. 1. Hackberry domes, Cameron Parish, Louisiana.

†Presented at the spring meeting of the Southwestern District, Division of Production, Rice Hotel, Houston, Texas, March 3-4-5, 1954.

*Stanolind Oil and Gas Company, Lake Charles, Louisiana.

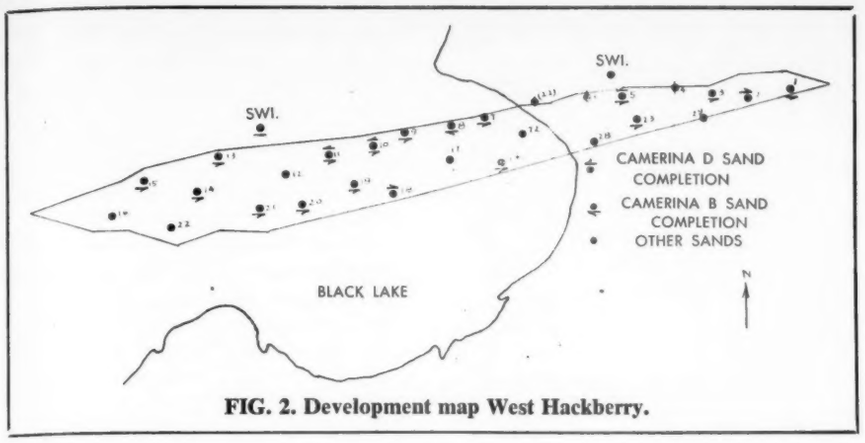

FIG. 2. Development map West Hackberry.

other two combined, and presenting the more severe production problems. As represented it has an average vertical thickness of 95 ft, and had a maximum productive closure of 1900 ft between depths of 8100 ft and 10,000 ft. The Camerina "C" sand, next in importance, has an average thickness of 106 ft, and a maximum productive closure of 1000 ft between depths of 8050 ft and 9050 ft. The Camerina "B" sand has an average thickness of 49 ft and a productive closure of 11,000 ft between depths of 8000 and 9100 ft.

Physical characteristics of the three sands and their reservoir fluids are very similar. The sandstone is medium grained and lightly cemented with a shaley matrix that appears quite competent under reservoir conditions, but breaks down readily on contact with fresh water. Physical characteristics have been evaluated in the laboratory by conventional core analysis, capillary pressure tests and special multiphase flow analyses. The reservoir crude oils which are undersaturated have been evaluated by conventional PVT analyses of bottom hole samples.

Average physical characteristics Camerina sands

Sand—	Porosity, %	30
	Permeability, Md	1500
	Interstitial Water, %	16
Fluid—	API gravity	30
	Solution Gas Oil Ratio	500
	Saturation Pressure	3300
	Reservoir Volume Factor	1.3

Camerina "D" Sand Injection

The Camerina "D" sand is producing under water injection pressure maintenance initiated in 1945. This sand was the principal objective of early drilling operations, and soon demonstrated a volumetric control mechanism. (Fig. 4) The initial bottom hole pressure measurements in the reservoir were made in January 1941 at which time 43,000 bbl of oil had been produced. Pressure averaged 4439 psi at a datum of 9600 ft. By January, 1942, eleven wells were completed in the reservoir, production had reached its peak level of 2500 bbl per day, 583,000 bbl of oil had been produced and the reservoir pressure had dropped 566 psi. Production rates were promptly reduced 50 per cent and a period of observation ensued.

The abrupt decline in pressure was an unexpected development in the area, previous experiences having indicated that water drive was the usual displacement mechanism. In the case of the "D" sand it was still expected that a water drive of some dimension would materialize, once bottom hole pressure had declined sufficiently to induce flow into the reservoir. The aim during 1942 and 1943 was to reduce producing rates by increments to a rate at which water influx would balance withdrawals and the reservoir pressure would be stabilized at a level higher than the bubble point. It was established early in this process that pressure could not be sustained at a desirable producing rate, and an experimental water injection pressure maintenance program was undertaken. Pending the initiation of pressure maintenance, rates were progressively reduced to a level of 25 bbl per well per day without stabilization of BHP.

The implications of the predominantly volumetric nature of the reservoir are of course obvious. According to concepts prevailing at the time, it signified relatively inefficient recovery of oil from the sand, as compared to expectations in a water drive reservoir. Loss of productive capacity with pressure decline and an extended and expensive reservoir life during depletion by artificial lift are inherent in volumetric type reservoirs. In this case, moreover, the bottom 300-500 ft of the oil column had been penetrated by only four wells in the entire 11,000 ft length of the reservoir and none of the wells encountered the oil-water contact, consequently the prospects of recovering an appreciable portion of that reserve

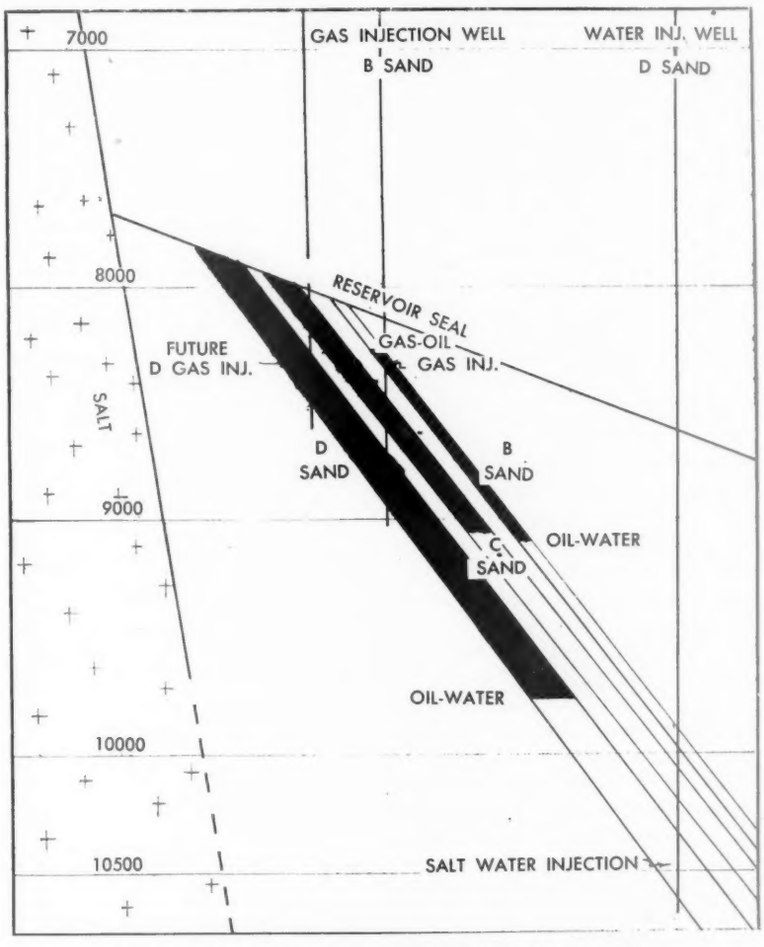

FIG. 3. Schematic cross-section West Hackberry unit.

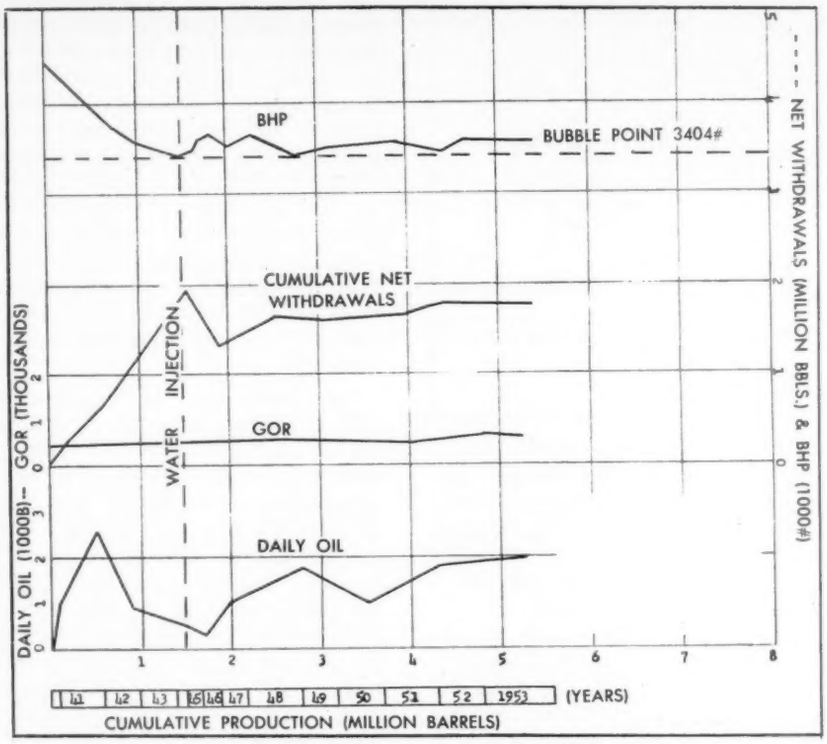
BHP
BUBBLE POINT 3404#
CUMULATIVE NET WITHDRAWALS
WATER INJECTION
GOR
DAILY OIL
DAILY OIL (1000B)-- GOR (THOUSANDS)
NET WITHDRAWALS (MILLION BBLS.) & BHP (1000#)
41 42 43 44 45 46 47 48 49 50 51 52 1953 (YEARS)
CUMULATIVE PRODUCTION (MILLION BARRELS)

FIG. 4. Camerina D sand performance.

without drilling a lower band of wells were dubious at best. (Fig. 5)

By contrast, water injection pressure maintenance promised a much higher recovery factor without shrinkage losses, sustained productive capacity during well life, and a means of eliminating the need for downdip development. The latter advantage was offset to some extent by the requirement for injection wells. It was believed, however, that several factors would facilitate a fairly uniform upward movement of the water-oil contact even though a minimum number of injection wells might be used. The high permeability of the formation would minimize the type of pressure gradients that induce coning. The high angle of dip and the appreciable difference in density of the reservoir oil and salt water should generate a healthy gravity force tending to cause the water to seek a level rather than rise irregularly.

The principal unknown was the critical factor of reservoir continuity, without which a uniform flood could not be obtained. Interference tests were of no value since the drawdown of most of the wells involved is within the limits of accuracy of present bottom hole pressure bombs. Pressure uniformity in the sand was encouraging, but withdrawals had also been relatively uniformly distributed, a consideration which rendered pressure data inconclusive.

The experimental project was initiated in February of 1945 with the objective of defining the feasibility of a program embracing the entire reservoir, and of maintaining reservoir pressure above the bubble point until a final decision had been made. The initial injection rate was 1500 bbl per day into the East salt water injection well, which had been drilled to serve the program.

The physical plant facilities at Hackberry in connection with the water injection project are not unusual. The source well, which produces salt water from a Miocene sand at an approximate depth of 2500 ft was necessary as laboratory tests on Camerina sand cores indicated fresh water was not suitable. There is no drawdown in the source well while delivering at the capacity of the pump even for extended periods of time. The average daily salt water production is about 3000 bbl. Water is delivered from the source well to a 100-bbl storage tank with a gas vapor blanket that prevents the injection water from coming in contact with the atmosphere and also serves to automatically control the amount of water delivered from the source well.

From the storage tank the water flows through a sand filter to eliminate the plugging of the injection wells by the removal of suspended particles. The filter is back washed daily but requires no other maintenance. Water from the filter is chemically treated to eliminate scale formation and flows into a manifold arrangement with separate metering facilities to record injection rates and volumes into each of the injection wells. This arrangement also allows gravity or pressure injection selectivity into the wells.

Ordinarily the well adjacent to the handling facilities takes its daily quota of water by gravity. The other injection well which is situated about one mile away from the source well requires use of the pump. Injection into the wells has been relatively trouble free. On the few occasions that surface pressure had risen to the 600 psi output of the injection pump acidization of the wells has increased their injectivity to the original level. The first injection well was given special consideration during completion and was underreamed, gravel packed and screen was set. The second well, however, is a typical set-through completion with the entire sand interval perforated with both bullets and jet shots.

Producing rates were restricted during the first year until a substantial increase in reservoir pressure had been effected. Rates were increased gradually from 1946 through 1948 and monthly bottom hole pressure surveys were made to follow alterations in pressure distribution. The results of the

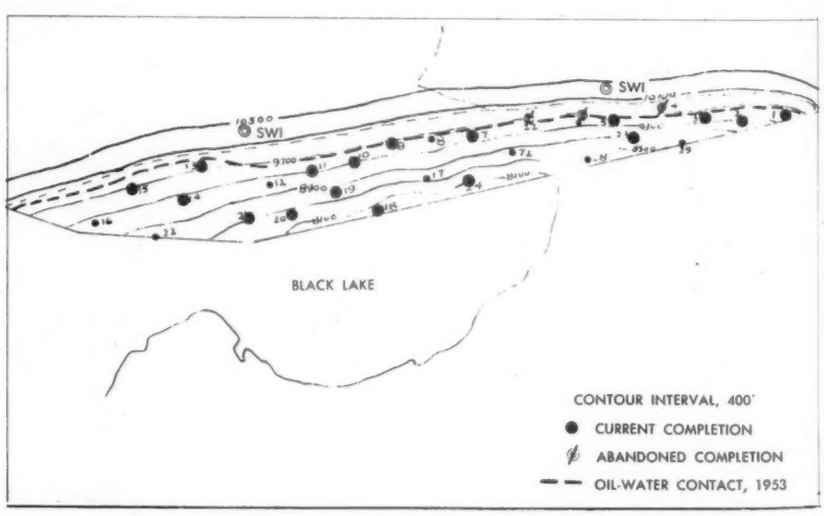

FIG. 5. Structure map Camerina D sand.

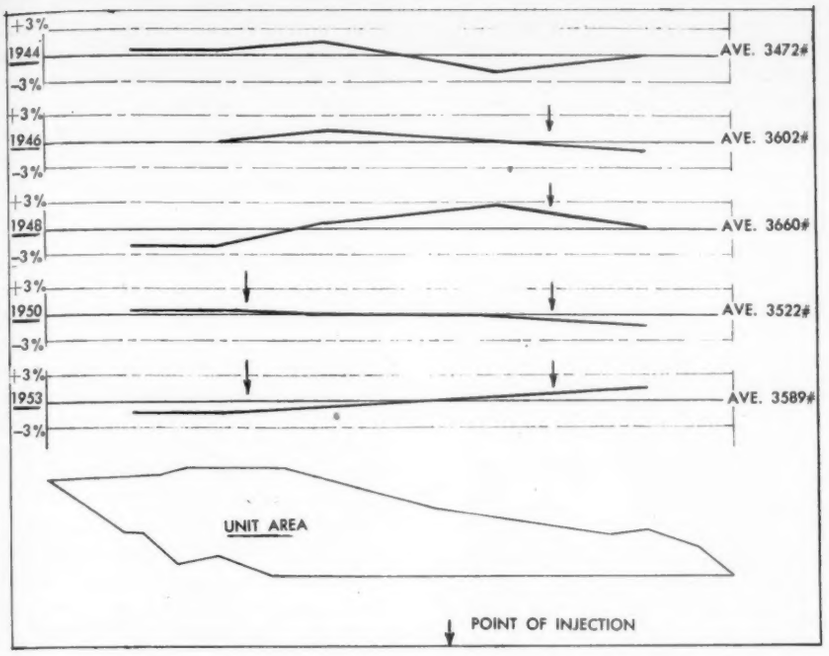

FIG. 6. Bottom-hole pressure profile Camerina D sand.

program were encouraging and it was decided to unitize the properties and expand to full scale operation. Although the pressure effects of injection were fairly uniformly transmitted to the extremities of the reservoir, (Fig. 6), there was a possibility for non-uniform movement of the water level. To prevent this producing rates were again restricted in 1949 pending the conclusion of unitization negotiations, and were not restored to higher levels until the unit had been formed and another injection well added.

Operations were restored to normal in late 1950. Division of injection volumes between two wells would tend to mitigate any irregularities encountered in the rise of the water contact, however, a further improvement was effected by regulating individual well allowables in proportion to their distance from injection wells. Any irregularities that remain are thought to be attributable to permeability variations that permit rapid advance of water through a small proportion of the pay. These do not interfere seriously with our plans, and as no wells have completely flooded out that have not logically done so as a function of depletion, we are satisfied that the operation is successful up to the present time.

The water level now stands at approximately 9700 ft by virture of the injection program, and in the course of this advance we have recovered more than 4,000,000 bbl of oil, a large proportion of which was displaced from a position below the "D" sand intervals in the existing wells. This has been accomplished for the investment equivalent of three wells, two of which were actually drilled for injection purposes. By comparison with depletion drive, and neglecting any variation in recovery factor for reasons discussed below, substantial additional gains have been realized through prevention of shrinkage losses.

Camerina "B" Sand Injection

The Camerina "B" sand is subjected to a gas injection program initiated in 1950. This sand was of secondary importance during the initial development of the field, the majority of the completions in it being made dually with the Camerina "D" Sand.

As a result of retarded development, production did not exceed 300 bbl per day until 1943 when the dual completion campaign got underway. (Fig. 7) During the period, reservoir pressure remained stable at the original level of 4140 psi at a datum of 9000 ft, and the reservoir was interpreted to be under water drive control. As producing rates were increased, however, the reservoir sustained a pressure drop as abrupt but less severe than that observed in the Camerina "D" sand. Rates were consequently restricted in 1944 to 1500 bbl per day as a first stage in seeking an equilibrium rate. In this case the bottom-hole pressure stabilized at the reduced rate, verifying the water drive concept, and exploitation proceeded in the manner typical of such pools, the producing rate declining as completions flooded out.

It is not difficult to conclude from this record that the gas injection project had its inception in other aspects of the operation than observed performance. Actually, there were three principal considerations involved. First, the prospect of early flood-out of the remaining "B" sand completions; second, the necessity of updip and pinchout development to deplete all of the Camerina sands and third, the possibilities of gravity drainage as a production mechanism.

The first two considerations are self-evident. Of the 27 wells drilled in the unit to date, 10 were situated low on the structure and 16 below midstructure. With all sands producing under natural or artificial water drive, avail-

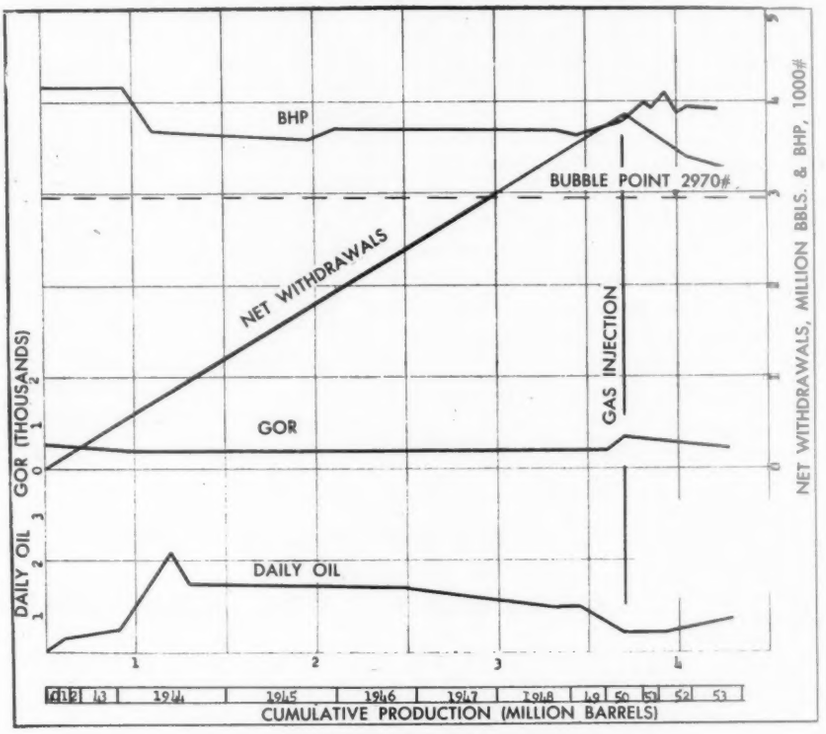

FIG. 7. Camerina B sand performance.

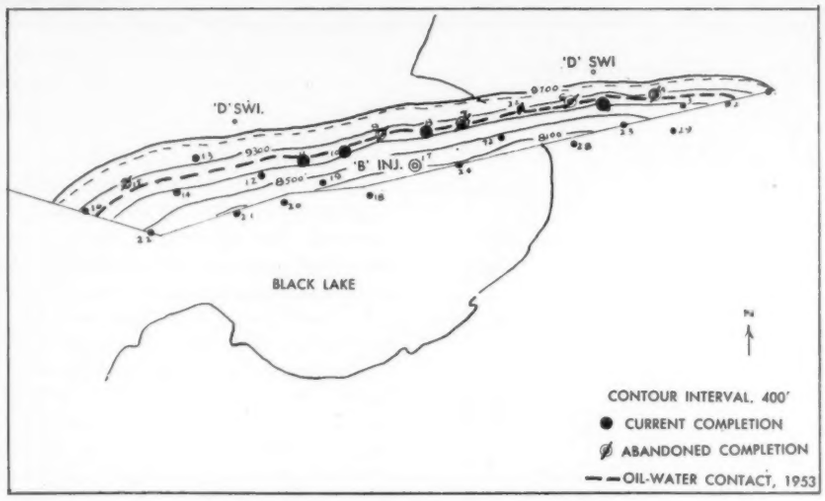

FIG. 8. Structure map Camerina B sand.

able wells would be reduced by one-third before a quarter of the reserves had been produced. This deficiency would have to be made up by additional drilling or sidetracking designed to provide completions as close as possible to the up-dip pinchouts in three sands. The possibility of obtaining completions right at the pinchout would be slight.

A single alternative presented itself in the growth of a better understanding, industry-wide, of the role of gravity drainage in depletion drive reservoirs. A few gas injection pressure maintenance projects had been designed for the express purpose of stimulating gravity drainage benefits. Here at Hackberry appeared to be an ideal situation for enlargement of the method. The high permeabilities and steeply dipping beds are ideally suited to the technique.

The method was advanced as a control that could stabilize water levels and maintain well utility. It was also postulated, with less certainty, that gas need not be injected at the apex of the structure to migrate into the pinchout and displace oil downdip to the available wells. As available information ascribed extremely efficient recovery factors to the mechanism, it appeared that the traditional superiority of water drive was too conjectural to be considered a valid condemnation of the proposal.

The "B" sand was selected for trial because it was most critically in need of stabilization to save wells, and because its smaller size affords a better opportunity to obtain data within a reasonable time for evaluation of the prospects of the technique in larger sands. Accordingly gas injection was initiated in the structurally highest well available, Hackberry Unit No. 17, in August of 1950.

Physical facilities for the gas injection project consist of a gathering system, which is connected to all the leases on the northwest flank, and a compressor plant. The plant consists of two 300 hp units which take gas from the gathering system at 65 psi and compress it to 650 psi. The plant is arranged so that the gas can be delivered to a third 300 hp compressor, which raises the gas pressure to the injection level of 3200 psi or if necessary, gas can be taken from the low pressure compressor discharge automatically for delivery to the field gas lift system. Ordinarily all of the gas is injected into the "B" sand, this averages about 2500 cu ft per day. Hydrate formation in the high pressure injection gas has been eliminated by a regenerative glycol dehydration unit. The injection well is an ordinary set-through completion and has been effective as both an injection and producing well. There has been no plugging of the injection well and since the original acid treatment no further work has been necessary.

Following the initiation of injection, withdrawals were continued at a restricted rate while the reservoir pressure was built up by over-injection. The purpose of this procedure was to force stabilization and, if possible, retirement of the oil-water contact in order to protect the remaining wells in the sand. The attempt was partially successful in that producing characteristics of one of the water producing wells improved slightly. This would indicate a definite but moderate recession in the water level. Further retirement of the water level is fairly unimportant and it is believed that the preferable policy for the future will be to balance injection and withdrawals with the reservoir pressure stabilized at a level compatible with adjacent formations.

Of interest with regard to this project, also, is the continuity of the reservoir and the ability of gas to migrate laterally along the pinchout. The only means of examining this aspect has

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been to maintain observation of the injection well in order to detect the passage of the gas-oil contact. This is accomplished by gently backflowing the well as opportunity permits to determine whether a permanent gas phase has been established at the level of injection. Thus far, it has been found that the injection interval resaturates in a matter of hours and the hole fills with oil. This prompts the conclusion that injected gas has in fact migrated updip.

It is believed that this experimental project has confirmed the correctness of certain of the concepts on trial, and the practicability of depleting pinchout oil by gas injection. Already more than 1,000,000 bbl of attic oil have been displaced and the gas-oil contact is still above the injection well, which is the highest completion in this sand.

Camerina "C" Sand

The Camerina "C" sand has exhibited a very active water drive. Some thought will be given to gas injection to recover attic oil in the final stages of depletion.

Future Operations

The experimental programs described above have not been free of problems. Together with laboratory techniques developed during their progress, however, they have provided much useful information to guide the conduct of future operations. Facilities are available in the field to exercise any degree of control desired to sustain maximum well utility throughout the life of the sands. We are satisfied that the fluid mechanics involved in regulation of water levels and displacement of pinchout oil are practical. In particular, research has devised means of assuring that gravity drainage recoveries are capable of equalling or exceeding those of water drive in reservoirs as favorably situated as the Hackberry units.

Although a specific plan for operating the various sands to depletion has not been developed as yet, considerable flexibility is available in this regard. Neither the water drive displacement of flank oil in the "D" sand, nor the gravity drainage displacement of pinchout oil in the "B" sand have progressed to a stage where a change in operations is necessary. Inevitably, however, exploratory investigations have been made as an aid in visualizing the manner in which gas and water injection can best be coordinated for efficient operations.

One such program contemplates an integrated pattern in which the Camerina "D" sand will be exploited concurrently by gas injection gravity drainage and downdip water injection until the water level is stabilized at a point just below the lower band of wells. At that point, with maximum recovery of downdip oil attained, the water level would be stabilized and final depletion would be accomplished through the lower band of wells by gas injection.

The "B" and "C" sands would be produced under natural water drive through wells transferred from the "D" sand as its gas-oil contact moves down structure. The final phase would consist of flooding the "B" sand up to the previously established gas-oil contact, displacing pinchout oil from the "C" sand by gas injection, and blowing down the stored gas reserve in the "D" sand for sale or injection.

By means of this program 26 of the 27 wells in the unit would retain their utility for 12 or more years. Nineteen of the wells would retain their utility for 20 or more years. Final depletion would be accomplished by 10 wells in an additional five to seven years. Thus far the recovery and operation of the programs at Hackberry have exceeded original expectations.

Acknowledgment

Authors wish to thank the management of Stanolind Oil and Gas Company for permission to prepare and present this paper. * * *

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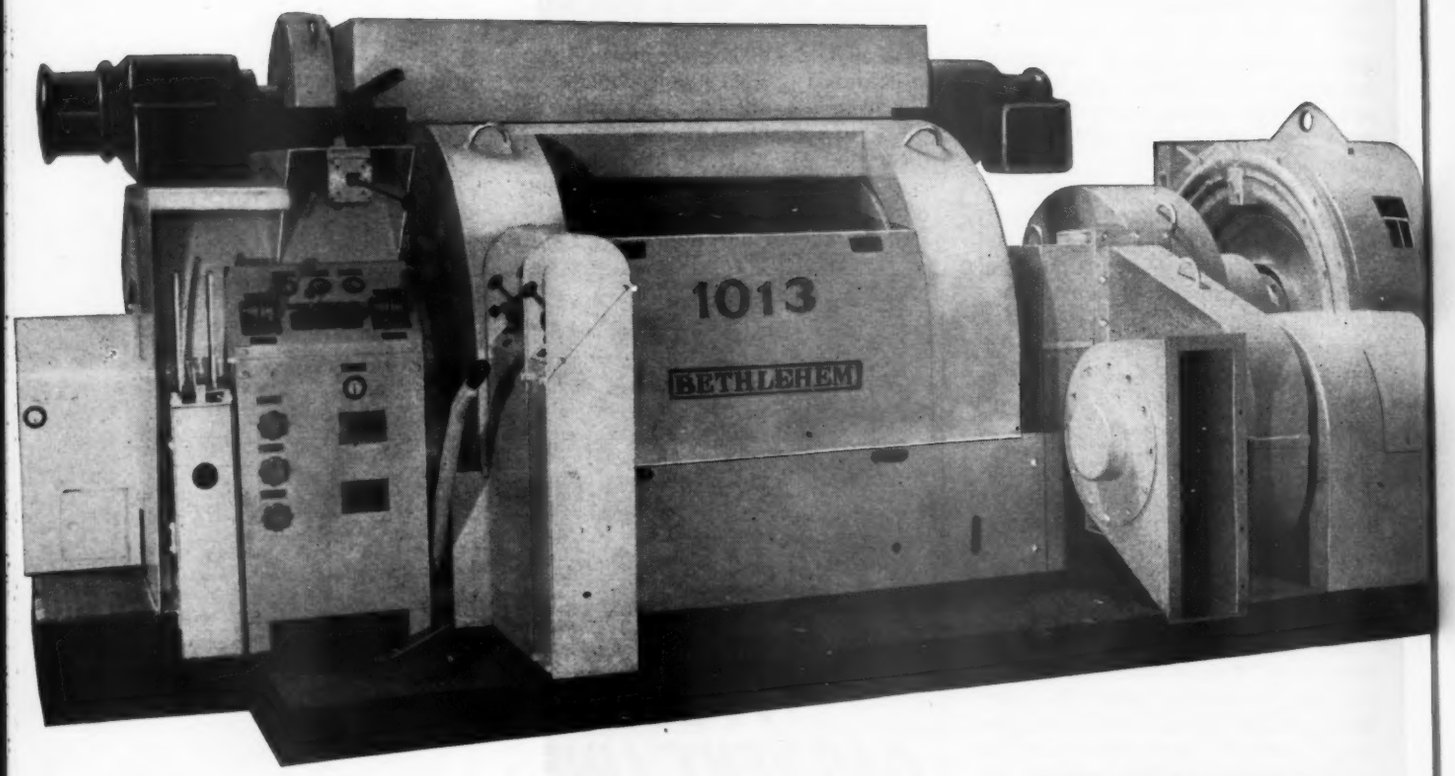
XUM



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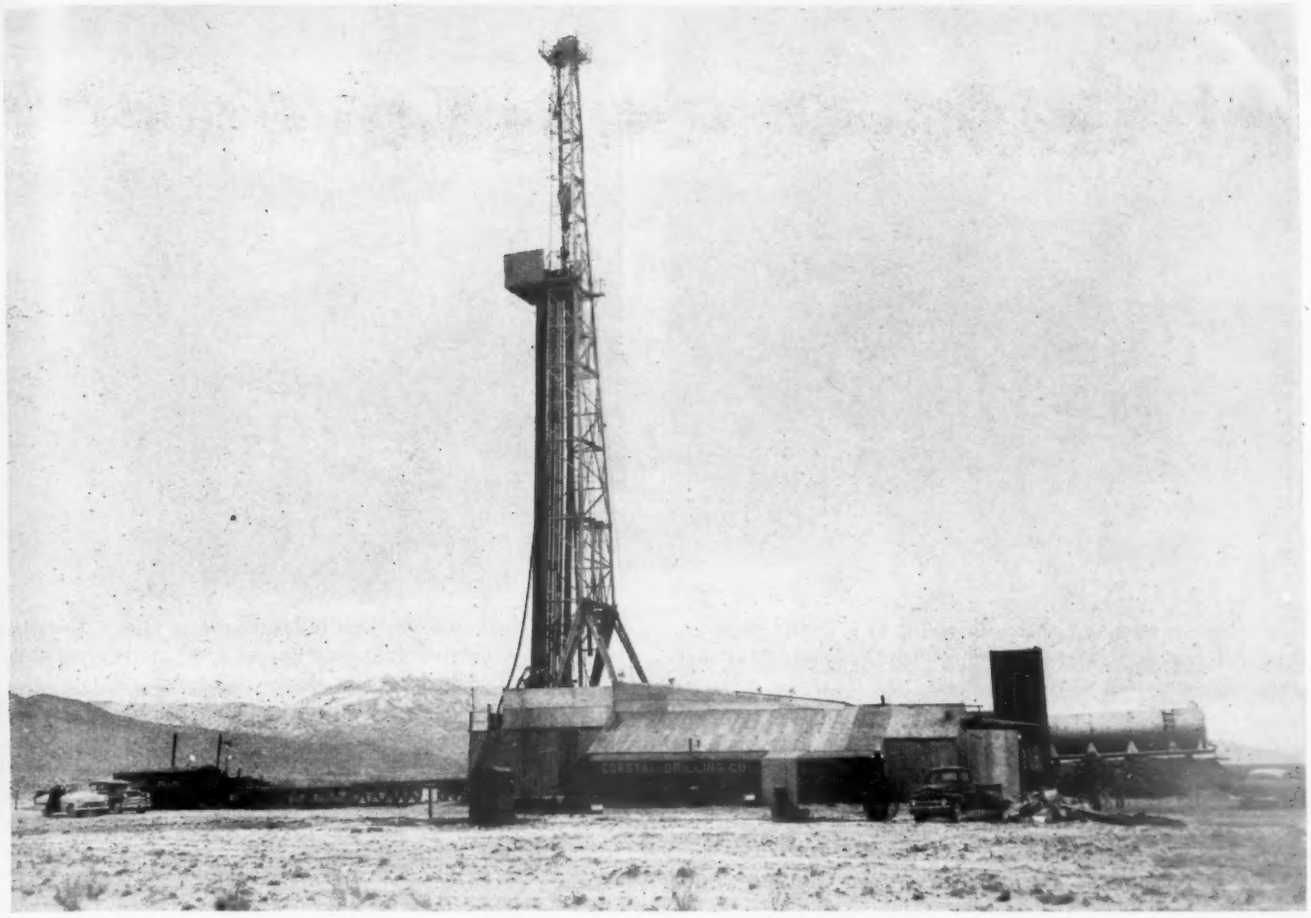


Coastal Drilling Company rig, which recently drilled the first promising oil well in Nevada, at the Shell No. 1 Eagle Springs Unit.

Nevada Test Holds Promise of Oil in the Great Basin

More significant than the fact that Nevada may become 29th oil state is fact that this 70,000 sq mile, sedimentary basin, which is almost completely in Nevada, may contain oil

NEVADA became the twenty-ninth state in the nation from which oil may be produced in quantity, when the Shell Oil Company recently reported the recovery of crude in the eastern part of the state. The new field is located in Nye County some 50 miles south and west of Ely. Drilling was continued after the report of a 185 ft oil section just above 6724 ft.

The well is Shell Oil Company's No. 1 Eagle Springs Unit which on a 4-hour test flowed 30 bbl of 26 gravity oil from a depth of 6453-6533 ft.

At latest reports Shell had topped limestone at 7318 ft, and has been drilling in interbedded lime, shale, and sand since hitting that depth. Some oil has also been recovered on a drillstem test made between 7376-7408 ft. The rig is capable of going to 10,000 ft, but Shell has not announced so far to what depth it plans to go.

Geology of the area where the well is situated is complicated, with location of the new test based on seismic evidence. Showings were made in the pyroclastic agglomerate (lava-like rocks of volcanic origin). S. F. Bowlby, Shell's vice president, termed the occurrence as peculiar, but said he believed present drilling was in Tertiary formation.

Bowlby added that the most significant thing about the showing of oil is that the Great Basin, which contains 70,000 square miles, has oil in it. The Great Basin is one of the largest sedimentary provinces in the country, and is almost completely within the confines of the state. It is almost as large as the U. S. portion of the Williston Basin.

Drilling for Shell is the Coastal Drilling Company of Bakersfield, California, operated by Fred M. Manning, C. T. Whitney, Bakersfield, and David G. Gordon, Denver, Colorado. Equipment includes 2 drawworks[1] powered by three diesel engines[2] and 7¾ by 16 mud pumps.[3]

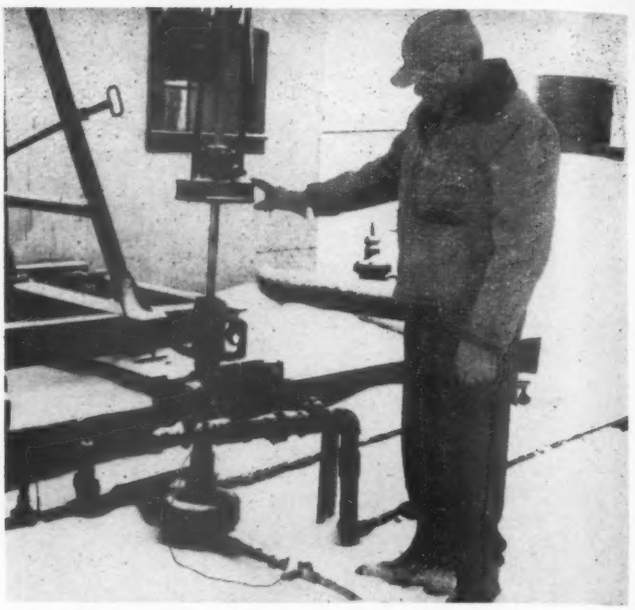
Also holding land in Navada are Standard of California, Signal Oil and Gas, Continental, Bell, Gulf, Phillips, George C. Atha, and Al Heller.

Standard and Continental drilled three exploratory holes in the past, with the last one in White Pine County. All made minor showings. Gulf recently abandoned as a dry hole its Federal No. 1 in White Pine County, nearer the Utah line. * * *

[1]Emsco J-750.
[2]General Motors.
[3]Gardner-Denver.

XUM

One of the heating units being inspected by a Carter engineer. The shell is of perforated pipe and contains a calrod unit similar to that in an electric stove.



There is little to be seen on the surface of a typical heater installation. Conductor cable and ground wires are in front of the feet of District Engineer Rex Davis.

SAND-FACE HEATER

Production increased in 3000-ft. Cut Bank wells after bottom hole application of heat with electric units

JOHN L. FERGUSON

MORE than 3000 ft below the drifting snows atop the Cut Bank field in extreme northern Montana, Carter Oil Company is using electric heating "pads" to warm the "feet" of oil wells.

This hothouse atmosphere Carter engineers are creating at the bottom of oil wells is an ingenious scheme to coax a little more oil out of the Cut Bank standstone.

Since 1951 Carter engineers have installed electric heaters in 23 wells. They plan to place heating units in 20 more this year.

Oil production increases of 8 to 43 bbl per day have resulted from the installations, according to Rex Davis, Carter's Cut Bank district engineer. The average increase, however, is about 8½ bbl per day per well.

The heaters won't work in every well. Nor is there complete agreement as to just how they stimulate production, although two principal theories seem to hold sway.

One group believes the heat melts off paraffin accumulations partially plugging face of producing sandstone.

The other theory is that the heat reduces surface tension of the "connate" water—water found in the formation with the oil. By relaxing the tight grip of the water on the oil, the heat allows the crude to flow to the well bore with greater ease.

The heaters themselves are the height of simplicity, so simple in fact that the original units were made in the field with a minimum of equipment. Because of recent refinements and the inevitable desire for neatness, the heaters are now produced at Carter's Tulsa lab.

The heart and soul of the heater is a calrod unit similar to the heating element in an electric range. The only difference is that the oil well heater unit is straight as opposed to the coiled units used in kitchen stoves.

Each unit is encased in a perforated pipe shell and attached to the bottom of the tubing string below the pump. Thus it always remains submerged at at the bottom of the well. The heater is installed opposite the best producing section.

The heaters use about 320 kw hours of electricity every two days. That's a full month's supply for the average home with an electric kitchen range. Because of heavy electricity consumption, it is obviously uneconomical to use the heaters where only minor production gains are achieved.

Carter engineers are currently spending considerable time in trying to determine the point of diminishing returns between consumption of electricity and higher oil production.

The practice at Cut Bank has been to run the heaters for 10 days to 2 weeks to step up production. Then, once production has begun to level off at its new, higher rate, we begin reducing heating time. The goal, naturally, is minimum power consumption and maximum gain in production.

Most of the heaters are operated only 30 to 40 per cent of the time.

Carter pumpers who turn the heaters on and off, are sometimes a little jealous of these oil wells with their toasty warm "feet." Like for instance one leaden, mid-winter day when the surface temperature at Cut Bank plummeted to 43 deg below zero. * * *

EXCLUSIVE

ECONOMICS OF THREAD LUBRICATION

Selection of right compound important because a threaded joint is only as good as the lubricant used with it

JACK C. BALLAGH

LUBRICATION of threaded members dates back to the invention by Archimedes of the threaded member itself, about 250 B.C. The advancement of thread design to its present engineered perfection has been paced by the advancement and improvement of greases that can be used with it, because without a proper grease even the best threads will fail, as will any bearing not properly lubricated. The thread member itself is really a bearing. It is a flat surface, narrow and long, that slides slowly over a like surface, generally of the same material. These surfaces must glide over each other with a minimum of friction, without cutting into each other, and without freezing to each other, causing what is commonly known as "galling." The starting load is zero, but the final load is generally close to the yield point of the material of which the threaded members are machined.

From discoveries made in the Pyramids and from studies of early Chinese art, it is thought that tallow from animal fats was the first grease used. After the development of soap it was found that the use of vegetable, fish, or whale oil gave somewhat higher melting points. When petroleum came into commercial use, new greases made from it had still higher melting points. These are the greases in common use today.

The melting points of straight petroleum greases, however, are often not high enough to withstand the high temperatures, speeds, and pressures required in modern industry. Engineers and scientists have, therefore, turned to the chemical industry for new lubricants, as failure of a threaded joint can, and does, upset all related problems. Without threaded members and their proper operation there would be no modern industry as we know it.

In view of the fact that a threaded joint is only as good as the lubricant used with it (as one cannot work without the other) it would seem that there is a problem of economics involved in the selection, purchase, and use of thread lubricants for all industry. This is certainly true of the petroleum industry, and because of this, the following discussion is confined to the effect of thread lubricants on oil field operations.

Cost of thread lubricants is such a small part of the total operating cost that the selection and ordering is often delegated to an inexperienced person or left to the discretion of the supplier who fills in on an order for miscellaneous supplies, such as waste, hand tools, rope, etc; however, there are many factors involved in selecting the proper lubricant for the important job it has to perform.

Before listing and discussing these factors, it seems advisable to study the equipment on which the lubricants are to be used and to mention the various kinds and grades of compounds offered for the different applications.

Threaded Connections

Practically all types of threaded connections employed in industry are used in the oil fields. One special style and type, however, is found almost exclusively in oil field operations. This is the "tool joint." Although a description of threaded members is rather elemental to most engineers, a review may illustrate certain points in this discussion.

The commonest thread, of course, is the straight thread as used in bolts and studs. (Fig. 1) The straight thread varies in accuracy from that of a stove bolt to which little tension is applied to that of accurately machined bolts of alloy heat treated steel, subject to great tension.

Probably the next most widely used are the taper threads on pipe and casing. (Fig. 2) This pipe can vary from line pipe where moderate pressures are encountered to that of deep well casing and tubing where extremely high pressure is experienced. Both types of threads must contain pressure without leaks. Threads cut on these tubular products are gaged to close tolerances as specified by the American Petroleum Institute or individual manufacturer if special threads are employed.

Of equal importance is the thread developed especially for the oil fields, the "tool joint" thread. (Fig. 3) This thread, like the pipe thread, is tapered so that it will "stab," or start. In addition, it is shouldered with faces that engage just as the threads "seat." These shoulders assure that the whole assembly will form the unit required as a driving medium for the drilling of the oil well. When once "made up" the threads are in tension and the joint will no longer continue to "make up" as is the case with the casing, tubing, or line pipe threads. Without these shoulders the "make up" is determined by the torque, or pressure, of the tongs. The joints permanently deform, both in this style, and in the shouldered thread. Heat is developed in the make-up due to friction, and deformation. The "tool joint" was the basis of a very famous patent issued some 30 years ago and is today a prime factor in modern deep drilling. Certainly the deep wells of modern times would not be practical without the use of the "tool joint" and the "tool joint" thread.

The shape of the threads themselves vary with the service requirements, the threads being V, square, and buttress type, with one to three square or taper shoulders or seals. No thread, however, escapes the basic requirements that the threads must slide over each other; and this sliding action must be accomplished with a minimum of friction and without seizure or galling.

Thread Compounds

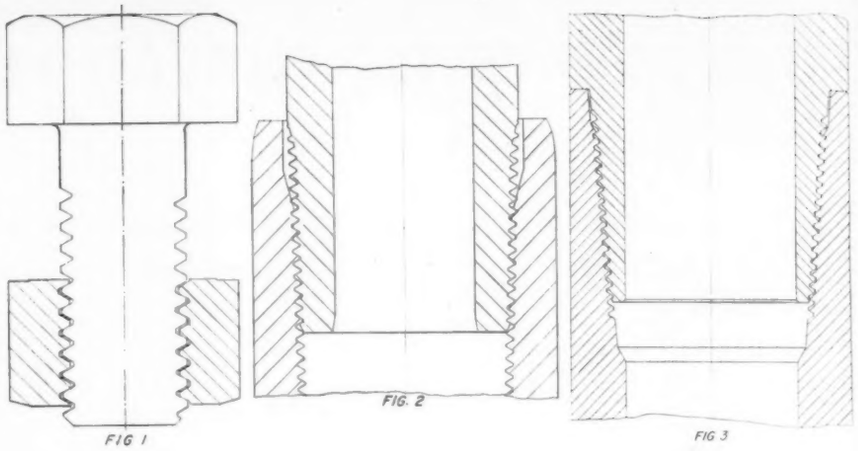
Some 20 or more manufacturers, in a highly competitive market, offer many different grades and types of thread compounds. Prices vary per pound over a considerable range. Without some method of evaluation other than

EXCLUSIVE

FIG. 1. A straight thread on which almost any thread lubricant is suitable. If subjected to high temperature, compound with high temperature resistance should be used.

FIG. 2. Taper thread without sealing shoulder, as on tubing or casing. Compound must have damming agents to provide seal in thread roots.

FIG. 3. Tool joint thread with shoulder. Compound should not build up in thread roots, and should allow frequent make-and-break without galling.



the claims of the maker, it would be easy to make the wrong selection of thread lubricant.

Certainly a lubricant for a stove bolt is not as important as one of the drill pipe, casing, or tubing of a well three or four miles deep. A number of different lubricants should be considered and selected for most efficient operation and proper quantities purchased.

The grades and composition of these compounds vary from red lead or graphite with oil, to those containing up to 70 per cent metallic lead or zinc. Some with molybdenum disulphide (MoS_2) are manufactured. Some have metallic copper with other solid lubricants or graphite. Others have compounds of the solids mentioned such as litharge, red lead, white lead, and zinc oxide. Some have a high percentage of fillers of "extenders" such as talc or lamp black. Most compounds are manufactured with a petroleum grease or "carrier." A few have given consideration to the newly developed hydrous silicas having "no drop" (nonmelting) characteristics incorporated in the carrier to meet the higher temperatures encountered.

Some thread compounds do not retain their metallic compounds in suspension and tend to separate in storage or under vibration. These must necessarily be puddled or stirred before application can be made. This is often difficult in the field and, thus mixed, complete redispersement of the solid components is often not assured.

Thread lubricants are now being offered that do not have to be thinned at cold temperatures, in fact can be applied without thinning at temperatures as low as minus 50 F. These are of value when mechanical applicators are being used.

Methods of Application

The brush is the commonest method of application. For lubricating casing and drill pipe there have been developed in recent years a number of mechanical applicators and sprays. These are finding an expanding market with operators as there is a better control of the quantity and uniformity of the lubricant applied. Contamination of the lubricant is avoided or reduced.

Selection of Lubricant

With this basic information or groundwork laid, it would appear that the factors involved in the selection of the proper lubricant would be about as follows:

1. Importance of the service.
2. Is the connection to be broken at some later date for servicing or operation?
3. Temperatures involved.
4. Pressures involved.
5. Corrosion and chemical factors involved.
6. The factor of safety of personnel.
7. The factor of safety of equipment.
8. The human elements involved.
9. Line products to be handled.
10. Uniformity of product. Packaging, marking, and identification.
11. Deterioration of product.
12. The problem of inventory.
13. The problem of logistics.
14. The hidden costs of improper selection for service intended.
15. Mechanical applicators and their effect on hidden costs, inventory, and safety.
16. Maintenance of an assured source of supply.
17. Tested and approved by users.
18. Ability to break properly for dismantling.
19. The initial cost.
20. Can these compounds be identified if containers are damaged or if labels are lost therefrom?
21. Can thread compounds be efficiently pumped with mechanical applicators?
22. Types of thread compounds to be selected and quantity required.

As to a detailed discussion of these factors:

1. **Importance of the service.** It would appear that a plain thread on bolts such as used on engine parts not subjected to either heat or weather, or line pipe that carries low pressure water or air, would not require an expensive thread lubricant. These connections may be in the minority so that for inventory and for purchasing simplicity it may be of small importance to try to make a saving that complicates stocks to be carried. One class of items to be carried may be eliminated by the use of a higher grade thread compound for this purpose. For important connections the highest grade thread lubricant for the purpose would appear to be the most economical in the long run.

2. **Is the connection to be broken at some later date for servicing or operation?** If the answer is "yes," then a compound should be used that is chemically stable and does not harden or set.

The Author

Jack C. Ballagh is president of Jet-Lube, Inc., which he organized in 1953. He was graduated from Colorado School of Mines in 1910 and was formerly president of Patterson Ballagh Corporation Extruders Inc. (of Los Angeles) and vice president of Byron Jackson Company. He has been active in the oil industry in California, Texas, Oklahoma, and Colorado since 1911.

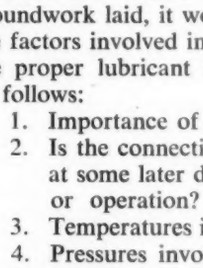


FIG. 4. Enlarged section of tool joint thread and shoulder. Crest of thread is missing. (Thread has been truncated or "topped" parallel to axis of taper of joint for purposes of "stabbing") Seal on pressure side (or flank) of thread against pressure is in the shoulder and profile.

FIG. 5. Same enlarged section as FIG. 4, showing lubricant that building up in root of thread preventing crest of thread to enter fully, causing stand off at shoulder. (A) Stand-off allows wash-out of joint or wobble and danger of broken pin.

FIG. 6. Brush application of compound. Coverage of thread and amount of compound placed dependent on operators care. Contamination prevention is difficult. Difficult to lubricate overflowing joint.

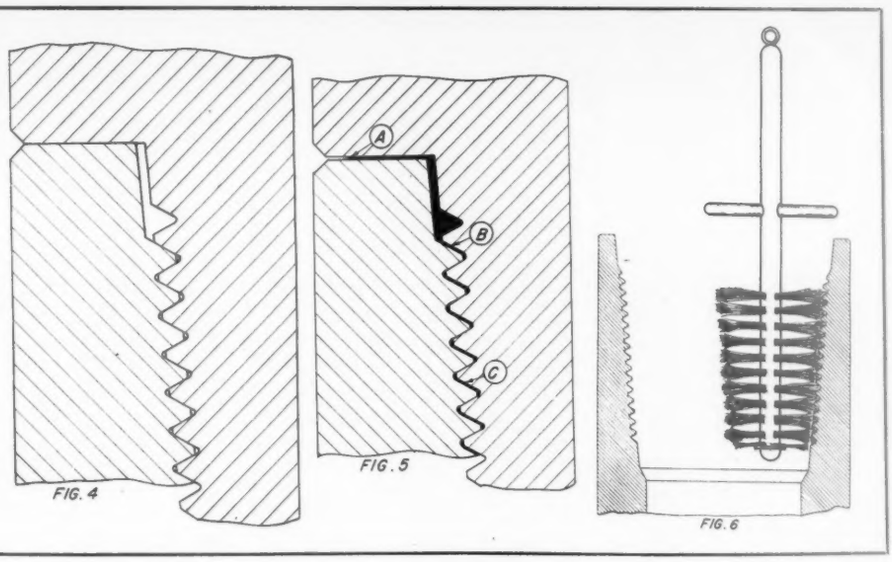


FIG. 4 FIG. 5 FIG. 6

Some compounds oxidize with age, resulting in corrosion. Stripping of a bolt or trouble with a connection may cost more than savings effected by buying an inexpensive but poor lubricant.

3. **Temperatures involved.** If temperature in excess of boiling water are encountered, particularly if high or moderately high for long periods of time, then a compound should be selected that is resistant to heat and will allow the joint to be broken without excessive torque, even after months or years of service. A simple test can be made by making up a bolt and nut with the lubricant, heating the assembly to a red heat with a torch, cooling in water and noting the torque needed to loosen. This is equivalent to a long period of time at a lower temperature. If the threads strip or the joint cannot be broken, the compound will not operate satisfactorily at high temperature for extended periods. Compounds should be able to withstand sub-zero temperatures without hardening if operations are subject to very low temperatures.

4. **Pressures involved.** If pressures are low, the selection of a lubricant is not as important as with high pressures. The thread lubricant must contain damming materials that will not only hold high pressure, but will hold it under vibration as well. Compounds should be able to withstand high pressures over long periods of time and allow breaking of the joint without excessively high torque or without galling. An example of this type of service is on tubing strings and threaded connections on "christmas trees" and well head manifolds.

5. **Corrosion and chemical factors involved.** If the connection is subject to corrosion (whatever the cause — rust, salt water, or contact with fluids or gases that contain corrosive agents) and the connection is to be broken, even years later, a compound should be specified that resists corrosive fluids or gases.

6. **The factor of safety of personnel.** This factor is of great importance, as no value can be placed on the life and health of employees, whereas as a value can be placed on the risks involved to machinery and equipment, such as the cost of a fishing job or the rethreading of a drill collar or even the loss of the well because of a casing leak. Many men have been hurt by sliding on a floor where a bucket of thread lubricant has spilled, and many floor men have been killed when the tongs broke while trying to "break" one of the tool joints of a string of drill pipe that had "frozen" due to "rough" drilling or because of improper lubricant application.

Some mechanical lubricant applicators have the advantage of keeping lubricant containers off the floor and in general are cleaner in operation than the brush-and-bucket method. The most efficient types give better and more accurate coverage of the connections than by brush. Better lubricant application to connections gives better break-out of threaded members.

7. **The factor of safety of equipment.** Like the personnel safety factor, this is sometimes overlooked in the selection of a thread compound. This factor may be the added thousands of dollars that the well may cost to complete, or it may even be the loss of the well itself. Is is one of the costs not generally attributed to a wrongly selected or applied thread compound. There may never be direct proof, but there may be suspicions and doubts. Who can deny that some fishing jobs may have been caused by foreign matter that found its way into the grease bucket and was picked up on the brush; that some rethreading jobs would have been avoided with a better thread compound, more uniformly applied; that tong dies that broke and fell into the hole would not have done so if the joints had not "broken" so hard.

That tongs would not have broken for the same reason; that the leak in the casing or tubing that necessitated a "squeeze" job might have been avoided with a better compound, more properly applied; that the caving of the hole would not have caused so much trouble if so much time had not been lost "breaking out" the string. The proper selection of the compound, with safeguards to assure its cleanliness and proper application can save much time and expense.

8. **The human elements involved.** The human element is mainly involved in the comparison between brush and mechanical application. "Tight" tool joints that neeessitated "tonging" are often caused by an operator who did not wait for the fluid to subside before applying the brush, or who did not apply enough lubricant so it was "dry," or did not remove water and mud from the threads, which sometimes drip from the thread just removed. "Washed out" joints can be caused by foreign matter on the brush or that has dropped into dope bucket, eventually finding its way into the thread. Leaks in casing or tubing can result for the same reason. Efficient mechanical applicators should provide a "closed system" of application where clean lubricant is applied, in the right quantity, reducing the human element as much as possible.

9. **Line products to be handled.** Compound to be selected should be resistant to a wide variety of products to be handled in lines such as water, steam, gas, crude oil, chemicals, acids, and

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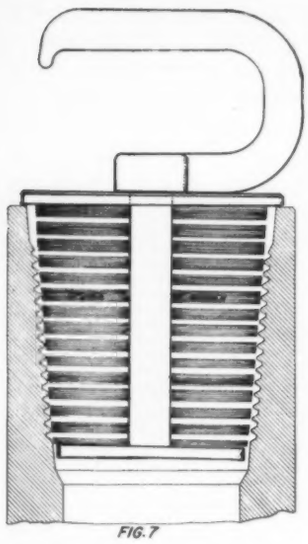

FIG. 7

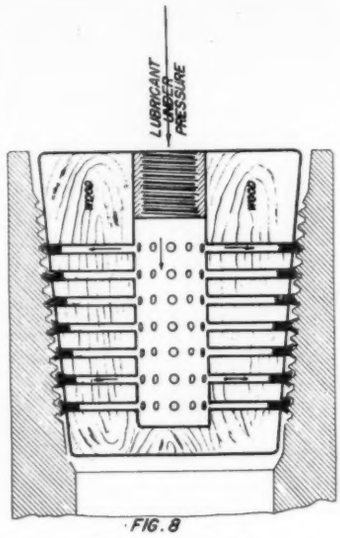

FIG. 8

FIG. 7. Fairly even distribution of lubricant on threads, but contamination prevention difficult. No control of amount of lubricant used. Pressure of lubricant application dependent on force applied by operator, but not sufficient to force contamination from threads. Sponge rubber swells causing difficulty. Cannot be used on rotating joint.

FIG. 8. Cone shaped brush. Lubricant pumped from cone. lubricant applied, but difficult to control amount placed. Pressure not sufficient to force contamination from threads.

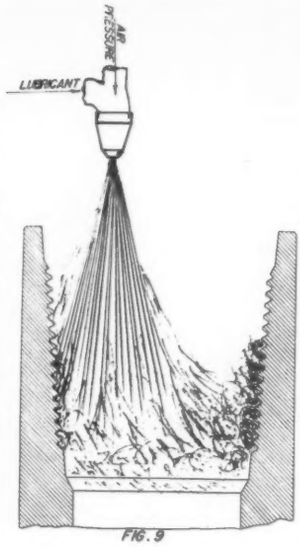

FIG. 9

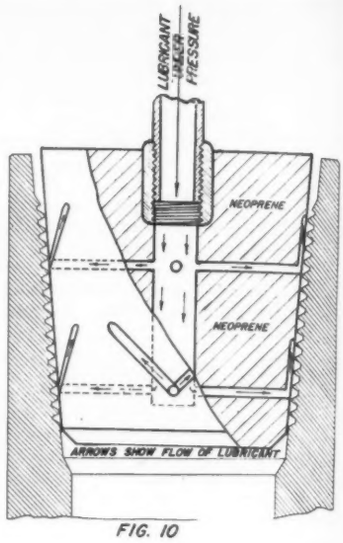

FIG. 10

FIG. 9. Spray type. Difficult to confine sprayed material to threads only. Difficult to control amount placed. Pressure not sufficient to force contamination from threads. Will not lubricate overflowing joint.

FIG. 10. Solid neoprene cone fitting across crest of threads. Clean lubricant forced between cone and threads under high presseure. Good control of amount placed. Pressure forces out contamination. Will lubricate overflowing joint. Cone swivel mounted and turns with rotating joint.

bases, and over as wide a temperature as possible.

10. **Uniformity of product.** The compound should be of uniform consistency and color. It should be of the proper consistency for easy application. It should not separate or bleed in storage or under vibration. Product should be properly mixed, milled or vacuum-pressure processed to insure uniformity and thereafter screened before packaging. Batch numbers should be shown on each container so that the user is able to refer the manufacturer to a definite batch in case trouble is encountered. Needless to say, compound should be packaged in clean containers of strong construction, properly marked and identified.

11. **Deterioration of Product.** The compound should not oxidize, settle out, or change its consistency when stored.

12. **The problem of inventory.** Selection of an efficient thread compound that can be used on a wide variety of applications over a wide range of temperatures, reduces inventory, saves transit costs, and reduces warehouse space required for storage. Mechanical applicators are reported to consume less lubricant than brush application on tubular products with a direct effect on inventory requirements, investment, taxes, and insurance. Simplification of inventory inhibits the chance of using improper lubricants for specific requirements.

13. **The problem of logistics.** This is often overlooked in the factors of thread compounds, and appliances with which they may be applied. This is of particular importance in overseas operations. If, as reported, applicators will cut the waste of lubricant by as much as 50 per cent, and the quantity used per joint can be very accurately measured, then the problem of logistics is to be considered. This would mean that but half the lubricant would have to be shipped; less bulk for train, barge, or truck, and less material for handling. It is comparable to the adjustment of the carburetor that will greatly reduce gas consumption. With an accurate estimate of the consumption per joint, calculation of the lubricant to be shipped can be made to adequately cover the job without running out or having an excess on hand when the job is finished.

14. **Hidden costs of improper selection for service intended.** These have been touched on elsewhere, but they include longer time to drill, with resultant added overhead and loss of production; inability to break connections when necessary; higher operating cost if leaks develop; costs of fishing and machine jobs; injury to personnel and equipment; increased transporation and inventory cost; and decreased life of equipment.

15. **Mechanical applicators and their effect on hidden costs, inventory, and safety.** Mechanical applicators for applying thread lubricants are rather new in the oil fields. Experiments with them seem to date back not more than five or six years. Most of the early styles were sprays of some kind, others being experiments with some type of fixed or rotating brush, fed from the inside or being dipped in the lubricant.

The ideal applicator should include the following features:

a. Assurance that no foreign material or contamination would enter the threads with the lubricant.
b. That the correct volume of lubricant, without waste, is placed in the threads and with even distribution over the entire connection.
c. Forced feed of lubricant to displace contamination (mud and water).
d. No lost time for lubrication.
e. Safe and simple for crews to operate.
f. Lubricant container to be off the working floor.
g. Free from complications, easy to service.
h. Light and inexpensive.

i. Easy to install on any rig.

j. Able to lubricate while drill pipe is still rotating in rotary table and drilling fluid is overflowing.

k. Adaptability to any size thread or type.

Mechanical applicators have definite advantages over brush application as they tend to spread the lubricant better, and make for a better breaking joint, but some have drawbacks that are quite serious. The spray type cannot properly lubricate the joint if the bit is plugged and drilling fluid is overflowing, unless a sinker bar is used to depress the fluid level. Even after being depressed the threads are still wet and they will not take the lubricant as well as a joint cleanly broken, or where lubricant is forcibly applied to the joint.

Further, the spray cannot be closely confined and is liable to spread compound on the outside of the pipe and prevent the tongs or spinning rope from functioning properly. The mechanical brush confines the lubricant to the joint but does not develop sufficient presure to force contamination from the joint. The dip type cone uses a container of grease on the working floor, which still is a menace to the safety of the operator and equipment, and does not safeguard against contamination.

One of the types of mechanical applicators confines the compound to an enclosed system preventing contamination, and pumps compound through ports in a closely fitting rubber head. This type develops high pressure in the threads forcing out mud, water, and contamination. The rubber head is swivel-mounted and turns with the pipe on the "break-out." It can be used on wet or overflowing joints as vertical relief holes are provided for mud passage.

This unit is slightly higher in cost than any of the other applicators, but users report savings up to 50 per cent or more of the lubricant, besides feeding a clean lubricant free from foreign matter. This device eliminates the hazard of the open bucket.

If the field reports are accurate, then mechanical applicators would be a very decisive factor in selecting a lubricant. A lubricant must be selected that can be pumped. If half as much is used as reported, a higher grade of lubricant can be purchased, without increasing the cost of application when compared to the brush method. With less lubricant used, a smaller inventory is possible, less load on transportation, less insurance, and a better knowledge as to how much to buy, knowing an exact amount is used per "break."

There is no doubt that correct lubrication will have a definite effect on hidden costs and speed of well completion. In use on casing and tubing threads it may mean the difference between a high pressure leak and a perfect "shut off."

Fig.	METHOD AND APPARATUS	Does application save lubricant?	Is amount applied closely controlled?	Can foreign matter enter containers?	Will application of lubricant force out mud and contamination?	Is bucket on derrick floor?	Can lubricant be applied while pipe is in motion?	Can joint be lubricated with plugged bit or overflowing joints?	Is operation safe to personnel?	Is operation safe to equipment?	Is compressed air needed?	Weight of unit-estimated	Estimated cost of unit
6	Paint brush and open bucket	No	No	Yes	No	Yes	No	No	No	No	No	½#	2.00
7	Dip type of cone shaped brush	Yes	No	Yes	No	Yes	No	No	No	No	No	40#	40.00
8	Cone shaped brush with lubricant pumped to the brush	Some	No	No	No	No	Yes	No	Yes	Yes	Yes	80#	200.00
9	Spray style of lubricator fed from master container	Yes	No	No	No	No	Yes	No	Yes	Yes	Yes	90#	300.00
10	Enclosed style of power applicator, with close fitting rubber cone	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	90#	385.00

16. **Maintenance of an assured source of supply.** It is quite important that the lubricant be supplied by a firm having the reputation of keeping a standard of quality and an adequate stock ready for prompt shipment.

17. **Tested and approved by users.** The manufacturer should be able to furnish a list of operators who have tested and are using the product.

18. **Ability to break properly for dismantling.** A most important consideration, as the break may be made years after the makeup. The break should be clean and with a minimum torque and no galling.

19. **Initial cost.** As the total cost of thread lubricant for the whole job is such a very low percentage of the total cost of the job, it would appear good business to make this the final, but not deciding, factor. Initial cost of the compound may be the highest of the lubricants available but may be the least expensive in the long run, due to efficiency in service. A check of the cost per gallon instead of per pound might be of interest. Purchasers are often deceived by a "per pound cost" as some lubricants will weigh as high as 30 lb per gallon whereas others may weigh as little as 10 lb per gallon. Cost of a lubricant should be considered by fluid volume as a thread will require a certain volume of lubricant regardless of the latter's weight.

20. **Can these compounds be identified if containers are damaged or if labels are lost?** It would be of advantage if the various grades selected did not look like alike and could be identified by the warehouseman, or by the crew, if necessary.

21. **Can thread compounds be efficiently pumped with mechanical applicators?** This is important if a mechical applicator is to be used as otherwise there is trouble ahead. The manufacturer of the lubricant can arrange for such tests as are necessary. The lubricant must not settle out. Where usage with a mechanical applicator is specified, most manufacturers can condition their lubricants to have pumpability.

22. **Types of thread compounds to be selected, and quantity required.** A study of the requirements will indicate the type and quantity of thread lubricants necessary. Lesser grade compounds can be eliminated if higher quality grades are specified for standard inventory. The highest grade obtainable for drill collars and drill pipe should have the following characteristics:

a. *Must not settle out.* Thread compounds are mixed by machine. If they settle out, no amount of hand-mixing will make the mix again homogenous. The material applied will be either too thick or too thin, interfering with proper application. This may result in improper make-up and break out.

b. *Must not "build up."* The compound must not "build up" or "work harden" in the roots of threads. The build-up of solids in the bottom of the threads may result in joints which do not shoulder, resulting in "wobble" and

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"wash-outs." Pin breakage is high on unshouldered joints.

c. *Must "make-up" and "break" easily.* "Make-up" and "break-out" torque should be low. High torque make-and-break is hard on equipment and dangerous to the crew. The correct make-up and break-out without galling assures faster and safer operations. Molybdenum disulphide (MoS_2), finely ground, and in the proper amounts, is reported to aid "make-and-break" operations, reducing friction and giving longer service life.

d. *Should withstand both high and low temperatures. Should not melt in hot weather, nor solidify in sub-zero weather.* For service in the tropics or where high temperatures are encountered, high temperature resistance is of advantage. The drill pipe is generally lubricated as the pipe is withdrawn from the hole, thereafter the joints are either stood in the derrick, or racked in the hot sun, sometimes for considerable periods. In the Near East these temperatures are known to be as high as 180 F, as the metal absorbs the full heat of the sun.

If the compound melts and runs, the threads will not be properly lubricated and can rust. A compound that congeals in cold weather can also cause trouble, unless it is properly thinned for efficient application. This is often difficult on the job and causes adulteration of the basic products as originally compounded.

e. *Must remain semi-plastic for long periods of time for pipe storage.* If the same compound used in drilling or casing a well is used for pipe storage, it should be highly resistant to heat, water and water vapor to prevent rusting. It should not dry out, crack, or peel after application. This is of particular importance in high humidity areas.

f. *The compound should contain efficient rust and corrosion inhibitors.* It is most apparent that efficient rust and corrosion inhibitors be incorporated in the compound to protect threaded surfaces.

g. *Non-fluorescence.* If formation cuttings are to be tested with "Black Light," a non-fluorescence specification should be inserted.

h. *Special selection for casing and tubing.* The function of a compound to be used on casing and tubing threads differ somewhat from that used on drill pipe tool joints. As the drill pipe is run in and out of the hole frequently, the feature of make-and-break is very important.

In the case of casing and tubing, however, the main function of the compound is to seal as well as lubricate. The pipe is run in the hole and remains there without breaking for long periods of time. It is important, in the case of casing and tubing, that the compound should have low torque characteristics so that full make-up may be realized, so that the highest efficiency for which the joint was designed may be effected.

Chief function of the compound should be to allow full make-up of these threads to provide the fullest pressures, high temperatures, and vibration. It is therefore apparent that the requirements of a compound for casing and tubing differ from tha trequired for use on drill pipe tool joints.

A compound that would give perfectly satisfactory service on drill pipe, allowing the pipe to be made and broken without any difficulty could possibly not have proper sealing qualities for use on casing and tubing that might leak after the strings are run. It would be advantageous to have a compound suitable for both drill pipe and casing and tubing; however, because of the difference in the requirement of the compound, it is apparent that the compound be selected for its intended use. For this reason it is generally recommended that two compounds are necessary, one principally for drill pipe and one for casing and tubing.

The square shoulder of a tool joint gives a seal when properly made up, but in the case of tubing and casing, square shoulders are not provided and the seal must be maintained in the threaded section of the joint itself. It has been shown that metallic lead or zinc compounds, when made up, sometimes tend to roll, allowing channels to occur in the threads, causing leaks under pressure. Some consideration has been given to special compounds utilizing lead and graphite, but with an additional enrichment of finely devided metallic flake copper that causes a matrix to be formed.

This practically eliminates channeling, thus assuring that a pressure type seal is maintained. It has been previously believed that thread compounds having a high solid content were most efficient in giving good sealing qualities. Recent studies have shown, however, that these compounds give relatively high torque in making up the connection. Tests have also indicated that compounds that give lower torque, allowing full make-up, give better sealing properties.

These tests also indicate that compounds with lower solid content do as efficient a sealing job in the thread as do those compounds of high content, and also have the advantage of allowing the joint to be made up with lower torque. The sealing property of the compound to be used on casing and tubing is very important. Manufacturers of this material should be able and willing to provide the user with test reports showing the efficiency of the compound for the service intended. Test data should show the efficiency as a sealing material and resistance to line products to be handled.

Conclusion

To obtain the fullest efficiency from threaded connections used in the drilling and production of oil and gas, and to maintain trouble free operation, the selection of thread compounds used on these connections is extremely important. The design and function of the connection determine the type of compound to be used. Operating conditions vary and a good compound must be serviceable over a wide range of operating conditions. Many compounds are manufactured and many formulaes are used.

It is obvious that some compounds could be, and probably are, more satisfactory than others. The more expensive compounds probably are more efficient than the cheaper grades, otherwise they would soon lose their market.

Improvements in compounding have been made in recent years employing new materials to prevent galling and seizing, as well as to resist both high and low temperatures. It is probable that further improvements will be made, both in the compounds and in the methods of application, as continued studies are being made of this subject.

Many factors must be considered to evaluate a thread compound besides the initial cost. The most expensive compound may be the cheapest in the long run when efficiency in service, protection to equipment and personnel, and flexibility over a wide range of application and operating conditions are considered.

The best lubricant will not give satisfactory service unless applied properly. Contamination is the enemy of efficient lubrication. Special precautions should be taken to avoid contamination or adulteration of compounds used, both in the container and during application.

Mechanical applicators are appearing in service that offer advantages over hand application of lubricant. These tools are designed to prevent contamination of lubricant, give better coverage of threaded connections, force contamination out of threads, allow better control of lubricant placed, and eliminate waste. Mechanical applicators vary in design and have various advantages and disadvantages.

The importance of proper lubrication of threaded members cannot be minimized. * * *

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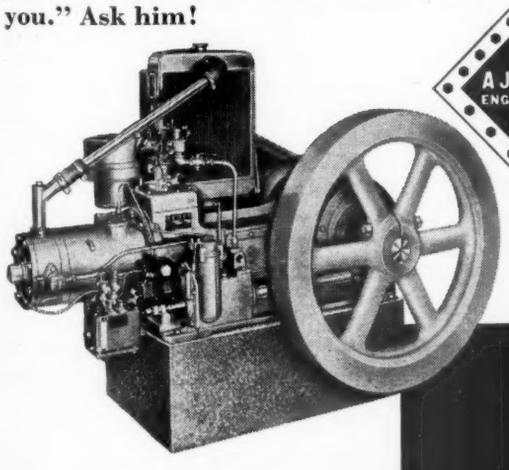

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WHAT'S DOING IN DRILLING

E. W. Masters, executive assistant to the vice president, Shell Oil, right, accepts for his company the American Petroleum Institute's safety award of honor from Frank G. Wilson, director of safety and fire prevention, API. Presentation of the award was made in recognition of Shell's Pacific Coast exploration and production record of 1,237,971 man-hours worked without a lost-time accident.

KANSAS

★ Bishop Oil Company announced its Webster No. 2 well has been brought in as a producer on an 80-acre lease in Pratt County. The well was given an initial potential of 2065 bbl per day by the state of Kansas. Present production allowable is 35 bbl per day, flowing from 4400 ft. Oil is 37 deg.

Production was obtained by perforating with 64 jet shots at depths of 4244 to 4260 ft in the Viola chert, then acidizing with 1000 gal.

WYOMING

★ The Ohio Oil Company No. 2 Smith swabbed at the rate of 176 bbl of oil per day in the Walker Dome area of Hot Springs County. The well, a confirmation of the Phosphoria discovery in this area by Forest Oil Corporation, produces from 6690-6700 ft. This pool is immediately north of depleted gas production at Walker Dome.

CALIFORNIA

★ A recent discovery, the No. 3 Emenhiser, in the North Victory pool of Tillman county, has been confirmed by Union Oil of California. It was installing pump, after swabbing 264 bbl of oil, cut with 8 per cent water and 2 per cent basic sediment, in 24 hours. Perforations were made in the Cisco at 3050-62 ft. Well was plugged back to 3080 ft, from 5967 ft and set casing on plug.

★ Monterey Oil Company, et al second offshore well, Newport No. 2, has been completed and is producing consistently at a rate of 100 bbl per day of clean 19 deg + API gravity oil. Oil is producing on pump from a 100 ft interval bottomed at 3927 ft. It is 500 ft southwest of the original Newport No. 1, and was drilled to 7,210 ft. before being plugged back to 3927 ft for completion.

★ Union Oil has announced completion of its Jewett Fee 43X-24 in the Belgian Anticline field for initial production of 1660 bbl per day of 37 deg crude. The well, completed in Oceanic sands at total depth of 5798 ft is flowing through 30/64-in. beam.

LOUISIANA

★ Crude oil production was established last week in the Patterson gas field of St. Mary Parish, with completion of Southern Natural Gas Company's No. 1 Zenor, finished flowing 515 bbl of 39.8 gravity oil per day through a ¼-in. choke from perforations between 13,372-386 ft.

★ A new oil pay opened a west extension to the Bully Camp dome field in Lafourche Parish. Humble Oil No. 2 Delta Securities, gaged 292.8 bbl per day through a ⅛-in. choke from 10,978-88 ft. Gas volume was 198,000 ft.

★ A distillate well has been completed in the North Crowley field in Acadia Parish. Pan Am Southern Corporation No. 1 John Harmon flowed 670 bbl per day through ⅜-in. choke from 11,740-52 ft, the deepest zone for the field, with a gas volume of 6,000,000 ft daily.

TEXAS

★ A 3700-ft extension with another pay zone is assured the East Hoffman field, 8 miles southeast of Freer, in Duval County. Approximately 220 ft of clean oil was recovered in the test, open 30 minutes through ¼-in. and ⅜-in. chokes. Interval tested was at 2029-46 ft.

The well, Birdwell et at No. 1 Greene, has been deepened to 2070 ft, where oil-string is being run for completion.

★ Gulf Oil Corporation No. 1 Butler, west offset to the Glasco-Devonian discovery, has been completed. A 6-hour test in top of the Devonian from 12,554-12,579 ft produced at a daily rate of 2200 bbl of oil with no water.

The north offset, Plymouth Oil No. 1 Butler, installed pumping equipment for completion. Although this well found the Devonian only 15 ft low to the discovery, permeability was poor and recovery is low.

★ Honolulu Oil Corporation No. 4 Whitaker has been completed as the sixth Cambrian producer for the White Flat field. Calculated daily flowing potential was 498 bbl of oil a day through 9/32-in. choke, from perforations at 5600-52 ft.

★ Tide Water Associated Oil Company has dually completed Nos. 1 and 2 Barnsley in the Lea Field, Crane County, Texas, from the Connell and Ellenburger formations. On potenital test, No. 1 flowed 251 bbl through a ¼-in. choke from the Connell zone, from perforations 8194-8204 ft and 381 bbl through a 5/32-in. choke from the Ellenburger zone. Similiar rates of flow were obtained from No. 2 Barnsley.

NEW MEXICO

★ Tide Water Associated has completed No. 3 Anderson, Lea County, New Mexico, from the Paddock formation. It flowed 893 bbl through a ¾-in. choke from perforations 5210-5235 ft.

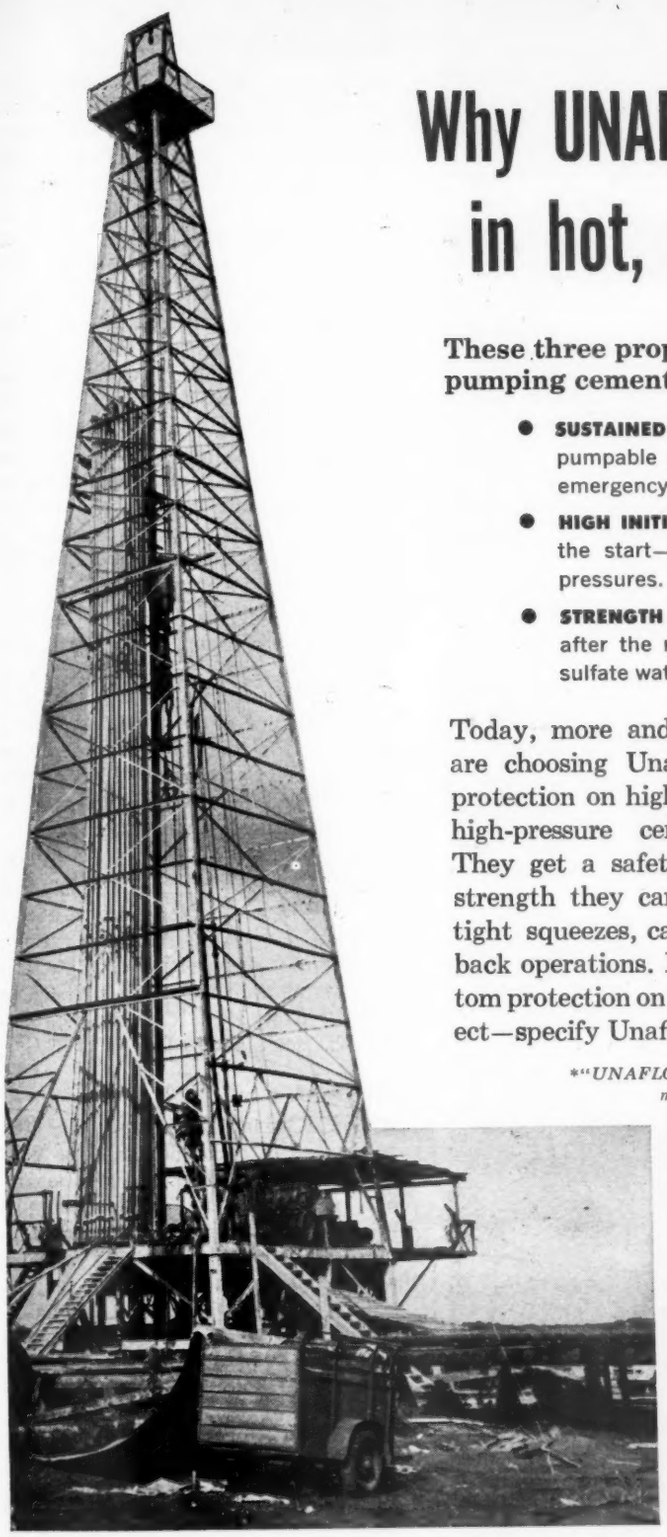
ILLINOIS

★ The Sailor Spring field, Clay County, Illinois, has been extended by Kingwood Oil Company, of Oklahoma City, with the opening of its No. 1 Keller-Stanfield. The well pumped 103 bbl from the Cypress sand at 2552-74 ft. Pipe was set on top of sand for open hole completion.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	March 15	March 22	March 29	April 5	April 12
Pacific Coast	155	148	140	135	140
Oklahoma	408	395	383	384	382
Kansas	161	163	148	166	155
Rocky Mountains	235	230	225	243	240
Canada	155	149	147	162	152
Ark-La-Tex	193	198	177	180	192
West Texas and New Mexico	499	490	461	482	490
Gulf Coast	503	532	532	546	562
Illinois	131	133	131	133	122
North Texas	313	316	310	325	314
	2753	2754	2654	2756	2749

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.



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- **HIGH INITIAL FLUIDITY** — Unaflo is easy-pumping right from the start—maintains fluidity under high temperatures and pressures.
- **STRENGTH AND DURABILITY** — Unaflo forms a strong, tight seal after the retardation period . . . highly resistant to attack by sulfate waters.

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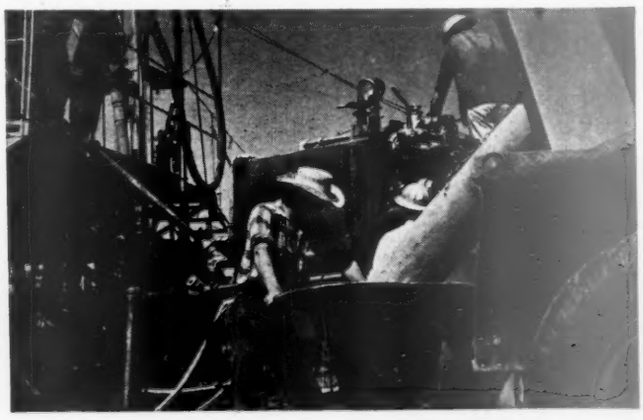

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Drilling

OKLAHOMA

★ With its No. 1 Logan, Sunray Oil has extended New Hope pool, McClain County, one-half mile to the north. Well flowed 84 bbl of oil a day through a ¼-in. choke from Hart sand perforations at 7418-24 ft and 7441-49 ft. Big Chief Drilling Company drilled extension, which set 7-in. casing at 7523 ft. Total depth was 7528.

★ In the northeast Lindsay field, Magnolia has completed at its No. 4 Central-Commercial, flowing 89 bbl of 37-degree oil, with gas-oil ratio of 505-to-1, through a 16/64-in. choke from Osborne perforations at 8407-34 ft and 8448-60 ft. Hart openings at 8178-8206 ft, previously tested at 36 bbl of 38-degree oil per day, were shut in. Well is plugged back to 8559 ft, with 7-in. casing at 9599 ft.

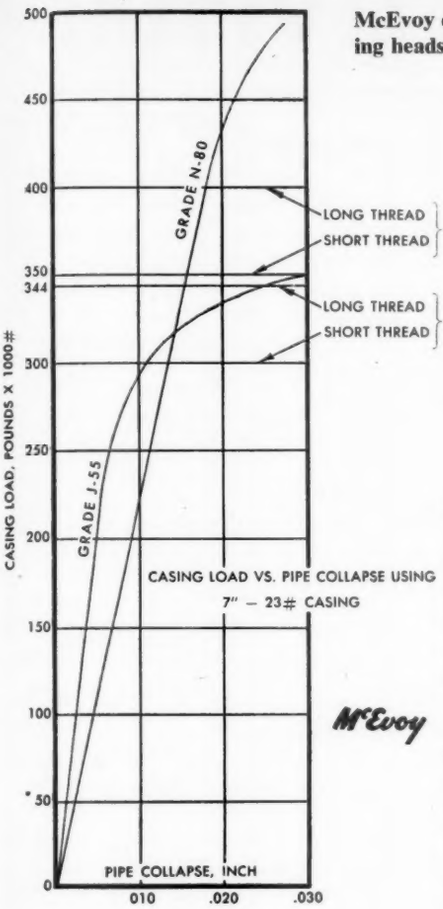
★ Texas Calgary Company has announced completion of its Texas Calgary Cobb No. 2 in the Southeast Cashion field in Logan County. Well was completed in the Hogshuter line, a new pay for the field, at a depth of 5572 ft and encountered 23 ft of pay. Well flowed 500 bbl per day of 42 gravity oil through a ⅝-in. choke.

★ In the Velma pool, Stephens County, Skelly Oil has completed its No. 3 Winans-B. Well tested 108 bbl of oil a day through 9/64-in. choke. Perforations were made at 3786-3854 ft, and the well was plugged back to 3863 ft from 3911 ft. Seven-inch casing was set at 3894 ft.

CANADA

★ The Canadian Oil and Gas Reserves Ltd.-Albermont No. 3 in West Drumheller, 90 miles east of Calgary, has been completed as a substantial D2 Devonian oil producer. After drill-stem test from 5555 to 5575 ft, when well flowed at a rate of 90 bbl per hour, crew set 7-in. casing to 5560 ft. On production test clean oil flowed at a rate of 61 bbl per hour.

Shell Oil Company's offshore development program to extend the limits of the Big Mineral field in North Texas is taking place from earthen fills extending into Lake Texoma. Lower photos show some of the 13 fills constructed at an elevation of 620 ft above sea level. Each fill, containing as many as three drilling platforms, has been covered with crushed limestone, creating the white appearance. Big Mineral Creek, partially under water, can be seen winding into the lake. Rig shown in upper photo is on Shell No. 19 T. D. Green. Earth used to construct the fills was dug from the lake bottom resulting in the small canals along the fills.



McEvoy diagram of new casing heads and hangers.

New Casing Heads, Hanger

Recently announced are new lines of improved casing heads and hangers that safely hang any weight of casing string to full coupling strength, and are said to eliminate dangerous "bottlenecking," by McEvoy Company, developers.

These "S" (step) heads and hangers are recommended for use in wells of all depths. Casing strings may now be designed and hung to full pipe strength, allowing the coupling strength to determine the length of casing string, or the load that may be applied with complete safety and dependability.

MONTANA

★ Shell reports recovery at a rate of 150 bbl of oil per day a test of Silurian at 34-33 Unit, Cabin Creek area, Fallon County. Test was of the interval 8357-8557 ft with a net of 148 ft perforated. Flow was through open tubing following treatment of the producing interval with acid.

★ Shell Oil Company has completed its confirmation wall in the Cabin Creek area, Fallon County. Operators had a flow of 259 bbl of oil from the Silurian at 8312-8540 ft through 17/64-in. choke.

★ Stanolind Oil and Gas Company has an offset to its discovery in the West Sanish area of McKenzie County. It is the New Year Many Ribs 1, which is a southwest offset to the discovery on temporary 160 acre spacing.

★ Dr. J. R. Van Pelt, director of Montana Bureau of Mines and Geology, has announced release of Reprint No. 3 "Raw Materials Resources of Montana." Special section is devoted to petroleum and natural gas production and location of fields.

★ Ohio Oil Company has a large well in Dry Creek field, Carbon County. Well is No. 24 Chapman, which was completed with a flowing initial production of 579 bbl of oil per day.

Gas Lift Problems ?

If you're ready to "flip your lid" with gas lift problems . . . take it easy and call your Merla engineer. Years of experience, gas lift engineering, and field "know-how" are at your service at any time.

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EXPLORATION ACTIVITIES

CALIFORNIA

★ Standard Oil of California has announced discovery of a new Ventura County oil field — tentatively known as the Fillmore field — with completion of its Sespe Ranch No. 1. The well was tested at the rate of 599 bbl per day net of 27.2 gravity oil producing from a Pliocene age sand known as the Spaulding.

The new discovery well is situated about three miles southeast of the Timber Canyon oil field and an equal distance northwest of the Bardsdale oil field. Production zone is 14,170-12,235 ft. The well was drilled to 14,314 ft.

★ Universal Consolidated Oil Company Twentieth Century-Fox pool discovery in Beverly Hills rated an initial production of about 500 bbl daily when completed in a deeper Miocene sand at about 7000 ft. Meanwhile the company is proceeding with the second well which at last report was nearing a depth of 6000 ft.

INDIANA

★ Another oil pool for Sullivan County has been opened by F. B. Cline at No. 2 Larr-Strawn, 3½ miles northeast of the Wilfred pool. On a four-hour test of the Devonian lime at 1933-58 ft it yielded 90 ft of gas, 2 gal of free oil and 45 feet of oil-cut mud. Five-inch pipe was cemented at 1937 ft.

NEW MEXICO

★ Schermerhorn Oil Corporation has extended the Monument field and has opened a new pay zone — the Queen sand — at its No. 1 Gulf-State, Lea County. The discovery is 1¾ miles north of Monument. Drilled to 3900 ft and perforated 3760-3880 ft, it tested 674,000 cu ft of wet gas a day.

COLORADO

★ Three States Natural Gas Company has completed its No. 2 White, 18 miles northwest of Cortez and five miles from the Utah line. Drilled to 6202 ft, pipe was set at one foot off bottom. Perforated in a Pennsylvanian reef, the well flowed 142 bbl of 48-gravity oil in 24 hours through a ¼-in. choke.

The field had been opened in December, 1948, by Western Natural Gas et al No. 1 Unit, which flowed 470 bbl of oil per day through a ⅜-in choke; gas tested 5,500,000 ft a day from pay at 5910-34 ft.

NEW VELOCITY LOGGER

A new oil exploration service, designed to provide detailed information about the vertical velocity of sound-energy travel through subsurface formations, has been announced.

Developed by Magnolia, the "continuous velocity logging" service is currently being offered to the oil exploration industry by SSC at its Midland office.

The continuous velocity logging is accomplished by running a sonic device on a conventional well-logging cable. This device consists of an ultrasonic signal, generator, which emits pulses at the rate of 20 to 30 per second. The generator is separated from the signal receiver unit by a 5-foot acoustical insulator.

The receiver unit detects the pulse and provides information for the measurement of travel-time between the transmitter and the receiver. These data are plotted by a special recorder. Since the formation velocity is nearly always higher than that of the fluid in the hole, the first arrival of energy at the receiver is that which has traveled along the "least time path" of the sidewall formation. Surface equipment is conventional seismic recording unit and velocity recording panel.

MISSISSIPPI

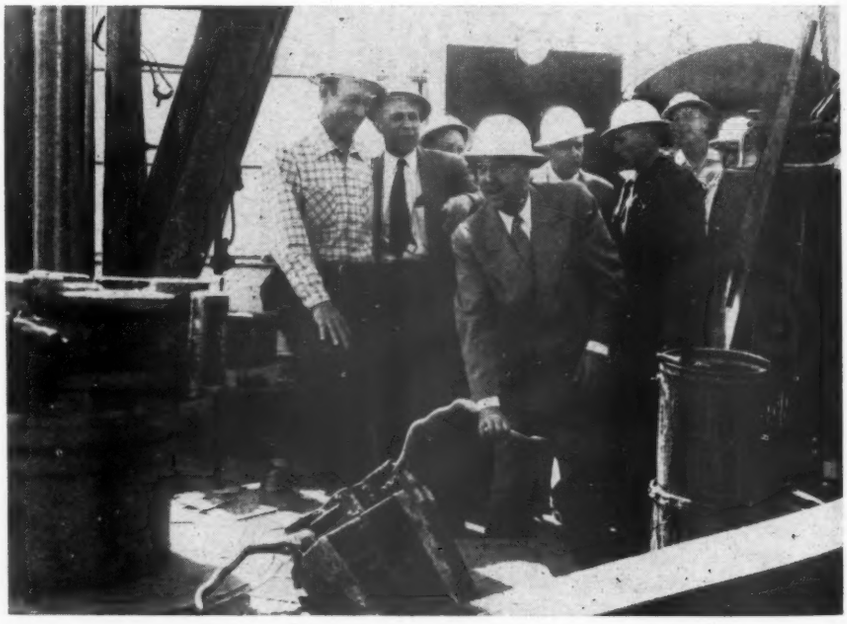
★ Honolulu Oil has a gas discovery in Calhoun County, at No. 1 Davis, 1¼ miles northeast of the Reid townsite. On test of the Abernathy sand 3274-90 ft, gas showed immediately, and was burned for more than an hour. Recovery was 70 ft of gassy mud with some condensate. A second test at 3290-3325 ft, also showed gas immediately, which burned in a dark red flare.

KANSAS

★ Oil Capital Corporation, Tulsa, added the 38th oil discovery for Kansas with completion of its No. 1 Welsh, one mile north of the Fort Zarah pool. The well was completed for a potential flow of 326 bbl of oil daily from the Kansas City-Lansing lime at 3278-84 ft.

MONTANA

★ Sun Oil Company's No. 1 Beagle Land and Livestock in Richland County is now testing lower zone in Madison. The wall was extensively tested between 9002-62 ft, with recovery of 140 bbl of oil in 12-hour swabbing test. It is scheduled to go to the Ordovician, and operator reports it may continue to this, depending on outcome of present tests.



Gubernatorial party including members of the Nevada State Oil and Gas Conservation Commission and headed by Governor Charles H. Russell, center, inspects Shell Oil Company's recent oil strike near Ely, Nevada. Governor Russell tries his hand as an oil well driller under the direction of W. C. Thompson, Shell drilling foreman, left, and S. F. Bowlby, Shell vice president. Seen in the background are C. H. Bunce, driller, Coastal Drilling; Hugh Shamberger, Nevada state engineer; S. S. Mitchell, drilling foreman, Shell; Charles Whitney, vice president, Coastal Drilling, and Dr. V. E. Scheid, commission chairman.

EXPERIENCE

A MEASURE OF QUALITY

The name "Core Lab" is synomymous with "Experience." Eighteen years' work in all active areas, under all types of formation productive tendencies, contributes greatly to the broad acceptance of Core Lab data by operators, purchasers of reserves, and state regulatory boards. The factual and interpretive qualities of Core Lab's Core Analysis Reports are measured by the experience of performing 25,000 individual core analyses and 700 different reservoir fluid analyses. Sooner or later you'll be faced with the question, "pay-out or play out"? Let Core Lab's experience establish your answer *now*.

DALLAS, HOUSTON, CORPUS CHRISTI, MIDLAND, ABILENE, SAN ANTONIO, TYLER, TULSA, FT. WORTH, WICHITA FALLS, OKLAHOMA CITY, ARDMORE, PAMPA, ARKANSAS CITY, GREAT BEND, NEW ORLEANS, SHREVEPORT, HATTIESBURG, JACKSON, LAFAYETTE, DENVER, BAKERSFIELD, WORLAND, STERLING, BILLINGS, CASPER, EL DORADO, LUBBOCK, FARMINGTON, LOVINGTON, CALGARY, EDMONTON, REGINA, CANADA, VENEZUELA, S. A.

Exploration

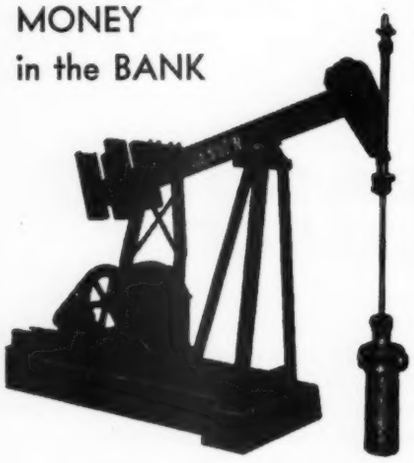
WYOMING

★ A highlight in Wyoming was a Curtis sand discovery in Fremont County. Skelly No. 1 Tribal reported a pumping gage of 231 bbl a day from casing perforations between 3265-95 and 3307-17 ft. Wildcat is between Circle Ridge field and Sheldon Dome.

SOUTH DAKOTA

★ South Dakota's first producer was announced by Shell Oil. Well pumping 80 bbl of 31 gravity oil and 200 bbl of water a day is No. 1 State A in the Buffalo area of Harding County. It is 30 miles southeast of Shell's Little Beaver production in Montana.

A JENSEN
in the field is like
MONEY
in the BANK



A JENSEN PUMPING UNIT costs less to install . . . less to operate . . . less to maintain. At the same time, you get greater production with more profit—and that's just like money in the bank!

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OKLAHOMA

★ Shell Oil Company completed a gas well in the Keyes area of Cimarron County, with its No. 1 Sparkman Unit, flowing 118,949,000 cu ft of gas a day through open casing after fracturing from the Keyes sand at 4530-92 ft. Well was plugged back to 4638 ft, after setting 5½-in. casing at 4670 ft.

★ Herman Brown, Houston, has opened a new gas-distillate pool northwest of the old Erick gas field in Beckham county, with the No. 1 Ham. Well flowed 32 bbl of distillate and 2,830,000 cu ft of gas a day through a ½-in. choke from perforations at 5636-46 ft. Discovery plugged back to 5822 ft from 10,294 ft and set 5½-in. casing at 5730 ft.

CANADA

★ A Toronto firm will probe the bottom land of Lake St. Clair off Windsor, Ontario, early in May in an effort to locate oil or gas deposits. Exploration effort will cover an 86,000-acre site extending out five miles from the Lake's Canadian shoreline 32 miles east and north of Windsor.

The project, hitherto attempted in only one of the Great Lakes, will be conducted on a license approved by the Ontario Cabinet, under a three-year lease carrying an annual rental of $21,900.

TEXAS

★ In the Vaughan field, Crockett County, Texas, Pure Oil has developed production in its first test to the Ellenburger. On a drillstem test the well, R. L. Vaughan No. 35, flowed at the rate of 250 bbl per day under a 1-in. choke. The crude is 41.5 gravity. Coring and testing is continuing.

★ Completion of the joint-interest Cummins J No. 1 multi-pay discovery in Ector County, for 1441 bbl daily has been announced by Cities Service. Completion test confirms previous indications that operators had a field discovery of major proportions. The well flowed at the rate of 872 bbl daily from 28 ft of open hole in the Ellenburger at 8900 to 8928 ft and 569 bbl daily from perforations opposite the Fusselman between 7770 and 7796 ft. It is completed to produce from both zones. Two additional pays were logged in Simpson sandstones. Total depth is 8928 ft, still in Ellenburger pay.

★ Three States Natural Gas Company recovered 3000 ft of 30-deg oil in a 70 min drillstem test of its No. 1 J. W. Hafner, Anderson County, along the banks of the Neches River. The well is a stepout to Humble Oil and Refining's recent Woodbine oil discovery. It was tested between 4510-41 ft in Coker sand, using a 1-in. top-hole choke and ¼-in. bottom-hole choke. Bottom hole flowing pressure was 765 lb. Shut-in bottom hole pressure after 30 minutes was 852 pounds.

PERU

★ Douglas Oil of California is preparing to develop a shallow zone that was discovered while drilling on the company's 122,000 acre Pacifico concession, lying along the northern coastline of Peru. The Douglas Pacifico No. 1 well logged and cored 110 ft of oil saturated sand between 1910 and 2100 ft, a showing good enough to justify an immediate test. There is enough acreage for a 30 to 40 well program in the area, since Point Lobo, which could be used for drill sites, extends 1800 ft out from the shoreline.

WESTERN AUSTRALIA

★ The Western Australian Petroleum Pty. is to spend $6,130,000 in 1954 to accelerate its oil exploration program in the territory — an increase of $2,190,000 over preliminary estimates. This company contemplates drilling 11 wells in the north-west of the state this year. To be drilled are six development wells to 3600-ft level at Rouge Range, Exmouth Gulf, in the second half of this year. When the present hole at Ampol Exploration's Rouge Range site is completed, it will be about three miles deep, and enable geologists to gage the nature of lithological formations to that depth.

The company envisages to continue the first bore to nearly 17,000 ft, and drill the second well at Rouge Range to test the extent of the oil-bearing formation. Drillings will also be made on Cape Range and in the Fitzroy River areas, approximately 700 miles northeast of Exmouth Gulf. The view that more oil may be found at deeper levels in the present bore at Exmouth Gulf is expressed by the Journal of the Department of National Development.

LOUISIANA

★ An oil discovery of major importance has been made by Union Oil Company of California in the East Lake Palourde area of Assumption Parish, Louisiana. Union Oil's William's No. 1, was completed flowing at a rate of approximately 250 bbl a day of 39.2 gravity crude oil. The flow is through a ⅛-in. choke.

ECUADOR

★ Manabi Exploration Company, Incorporated has announced an oil discovery in Ecuador on its government concession holdings in the Santa Elena Peninsula area. Manabi deepened its No. 81 well in the Achallann field from the present producing zone to about 1800 ft. The well encountered an oil sand at that depth, and flowed at the rate of 750 bbl daily.

McEvoy COMPANY
OIL WELL EQUIPMENT
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Safety in Landing Casing and
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We of McEvoy consider this superior well head equipment a major contribution to proper deep well completion. McEvoy is indeed pleased to be the FIRST to offer these outstanding products to the oil industry.

Yours very truly,

McEVOY COMPANY

C. F. Johnson
Executive Sales Manager

ATTEST:

Allen F. Rhodes
Director of Engineering

W. O. Hedrick
Plant Manager

RUNNING TOUR with MEN in the INDUSTRY

Gordon J. Buckle

Charles F. Gates

Milan G. Arthur

Gordon J. Buckle has been promoted to district superintendent, Southern district, The British-American Oil Producing Company. Formerly district engineer in B-A's central district in Oklahoma City, Buckle succeeds the late Errol J. Hesser. A graduate of Oklahoma A & M College, Buckle joined British-American in 1937.

C. E. Brandon has been promoted from field foreman to field superintendent. He will assume new duties in the Julesburg-Denver Basin. After graduating from The University of Oklahoma, Brandon began with B-A in 1950.

Charles F. Gates, General Petroleum Corporation, is general chairman of the 1954 spring meeting of the Pacific Coast district, Division of Production, American Petroleum Institute.

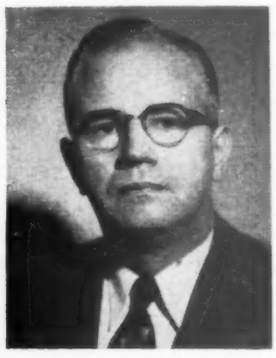
The meeting is being held in Los Angeles, California, May 6 and 7.

Milan G. Arthur, Union Oil Company, is 1954 chairman of the Pacific Coast district.

Feature of the drilling session is a symposium on oil well cementing and cementing practices. Two addresses will be made by J. R. Suman, Jersey Standard, and Raymond G. Moley, *Newsweek*.

E. W. Masters

B. P. Eastin



E. E. Emrick, Jr.

E. W. Masters has been named executive assistant to the vice president and **B. P. Eastin,** area production manager, for Shell Oil Company's Pacific Coast exploration and production area.

Masters, who has been area production manager since 1944, has more than 27 years experience in the company. He joined Shell in 1926. He was graduated from Stanford University in 1918. Eastin, who replaces Masters, has more than 15 years service with Shell. In 1951 he was appointed division production manager. Eastin is a graduate of the University of California.

E. N. Van Duzee, on special assignment in Shell Oil Company's New York office for the past year, has returned to New Orleans as Shell's area production manager. **J. W. Pittman,** who has filled the position of production manager during Van Duzee's absence, is now on special assignment to Shell's New York office.

Van Duzee, graduate of the University of Minnesota, joined Shell in 1926. He became production manager for Shell's New Orleans area in 1946.

Edward E. Emrick, Jr., director of purchases, has been appointed exploration-production manager of the Ashland Oil and Refining Company. Emrick joined Ashland after his graduation from the University of Illinois in 1931. During the last 12 years he has headed the purchasing department.

Frank L. Fisher continues as chief geologist of Ashland with increased responsibility for exploration activities. Fisher joined the company as a geologist in Evansville, Indiana, in 1943.

Another promotion in Ashland Oil's exploration-production department brings **Nace F. Mefford, Jr.,** to Ashland as chief production engineer. Mefford, a graduate of the Missouri School of Mines, was first employed by Ashland Oil in 1948 as a petroleum engineer at Henderson, Kentucky. He was production engineer at the Henderson office of the company before his transfer to Ashland.

L. W. Goodrich has been appointed production superintendent for San Jacinto Petroleum Corporation. Prior to joining San Jacinto Goodrich was associated with The Texas Company. He is stationed in San Jacinto's offices in Houston.

H. B. Gernert, Trigood Oil Company, Casper, has been elected chairman of the Rocky Mountain district of the American Petroleum Institute's Division of Production.

Gernert succeeds **J. Howard Barnett,** Casper petroleum consultant. Barnett was chosen chairman of the district advisory committee.

Dell C. Wade has been promoted to production superintendent for Crown Central Petroleum Corporation. His new headquarters will be in Abilene, where he has moved from Houston. He was formerly petroleum engineer.

Harry Dereniuk, formerly chief primary engineer, has been promoted to assistant chief engineer, exploration and production division, Deep Rock Oil Corporation. Among Dereniuk's new duties will be the engineering supervision of Deep Rock's secondary recovery projects. He will also supervise the company's evaluation personnel. Dereniuk was graduated from the University of Oklahoma.

Tom Gaines has been named chief petroleum engineer of Texaco Exploration Company, Canadian subsidiary of The Texas Company. Gaines has been assistant division petroleum engineer in the Rocky Mountain division of The Texas Company at Denver since 1950. His new headquarters will be in Calgary, Alberta, Canada.

He was graduated from the University of Texas, and after graduation he joined Texaco in 1940.

Charles F. Elder has been named staff petroleum engineer, Texaco. Elder has been assistant to the division manager of the company's Oklahoma division at Tulsa. His new headquarters will be in New York City. He was graduated from the University of Oklahoma in 1940, joining Texaco at that time.

G. M. Bell has been promoted to assistant to division manager, Oklahoma division of Texas' producing department, and **E. R. Filley, Jr.,** has succeeded him as division petroleum engineer. Bell will replace Elder.

Bell was graduated from the University of Oklahoma, joining Texaco in 1941 Filley attended Tulsa University, joining the company in 1942.

Vernon B. Zacher, registered engineer, has announced opening of new offices and laboratory. New address is 1241 Thompson Boulevard, Ventura, California.

Mark Clarke has been named treasurer of Republic Drilling Company, Tulsa, Oklahoma. A certified public accountant, Clarke was formerly associated with Parker Drilling Company, for the last eight years.

J. Edward Brantley and **C. Stribling Snodgrass** and Associates, geologists and engineers, have opened offices in Suite 707, Washington Building, 15th Street at New York Avenue, Washington, D. C. The firm will specialize in oil and gas developments.

What's NEW

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NEW SERVICES • NEW TOOLS
NEW WAYS OF DOING THINGS

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McCullough Log Through Casing *Proves More Accurate Than* Other Log in Hole!

REPORT FROM THE FIELD!

This was a wildcat well. Operator ran another type gamma ray log in open hole. Then 7", 23-lb. casing was set at 7320'.

McCullough was called to run a gamma ray log, primarily as a measurement check. It indicated that the first log was eight feet in error.

However, of even greater importance, it was immediately apparent that the McCullough log through casing was clearer and sharper, recording changes in lithology that were completely missed by the first log. Another example of the far greater efficiency of the McCullough Radiation Well Logger.

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Accurate, Consistent, Stable and Reliable Gamma Ray and Neutron Logs

The counter of the McCullough Radiation Well Logger, has an efficiency approaching 100% in measuring gamma radiations. It is approximately 100 times more sensitive per unit of volume than other radiation counters.

For Best Results Log AND Perforate by McCullough

Available in most active oil fields — call your McCullough Service Engineer and ask to see a log from your area.

PERFORATING, RADIATION LOGGING, AND FISHING TOOL SERVICE—ANYWHERE—ANYTIME.

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Running Tour

H. M. Christie, Jack Woodward, William T. Beard, Jr., 1954 TIPRO officers.

▸ **Jack Woodward,** Dallas, Texas, independent, has been named president of Texas Independent Producers and Royalty Owners Association. A graduate of the University of Texas, Woodward was employed by Magnolia Petroleum Company in 1937. He later resigned to head the petroleum corporation bearing his name, engaging for a time in independent consulting work.

H. Merlyn Christie, an independent oil operator with headquarters in Houston, was named secretary of TIPRO. He most recently served TIPRO as chairman of the membership committee.

William T. Beard, Jr., an officer of the Alamo National Bank of San Antonio, will serve his fourth term as treasurer.

▸ **G. A. Younie** has been named district superintendent for the Kansas producing district of Stanolind Oil and Gas Company. He replaces **H. L. Olson** who was transferred to Houston on special assignment. Younie attended Kansas State College, and joined Stanolind Oil and Gas in 1930.

W. R. Franey, formerly field engineer at Stanolind's Duncan, Oklahoma area office, has also moved back to Ellinwood where he becomes district engineer. He replaces **G. H. Lancaster** who goes to Rangely, Colorado, as field superintendent.

Replacing Younie is **V. B. Marsh,** who steps up from production foreman.

A. W. Lang, Jr., has been transferred from the West Edmond area to Duncan to replace Franey.

J. F. Carter, Jr., will succeed Lang.

▸ **Dr.Gilbert O. Raasch** has joined the staff of Denver Sample Log Company as paleontologist at the office of its Canadian subsidiary, Canadian Stratigraphic Service, Ltd., Calgary, Alberta, where he will do paleontological research.

▸ **Joseph S. Pluta,** formerly of Houston, Texas, has joined the supervisory staff of Century Geophysical Corporation. Pluta attended McGill University, Montreal, Quebec, and DalHousie University, Halifax, N. S. He has had seven years seismic experience in Canada and the U. S.

▸ **Don O. Freeman** has been named assistant to the president of Warren Bradshaw Exploration Company, Tulsa Oklahoma. A graduate of the University of Oklahoma, Freeman joined the company in 1949. The next year he was transferred to the Oklahoma City office.

▸ **Philip H. Kuenen,** department of geology, University of Groningen, Netherlands, and **Henry W. Menard, Jr.,** Naval Electronics Laboratory, San Diego, California, has received the Society of Economic Paleontologists and Mineralogists award for their paper "Turbidity Current, Graded and Non-Graded Deposits," published in the Society's quarterly *Journal of Sedimentary Petrology*, Vol. 22, No. 2 (June 1952).

Other award winner was **Lloyd G. Henbest,** U. S. Geological Survey, for his paper "Significance of Evolutionary Explosions for Diastrophic Division of Earth History," published in the Society's bimonthly *Journal of Paleontology*," Vol. 26, No. 3 (May 1952).

CAVINS-BENNY

quick change

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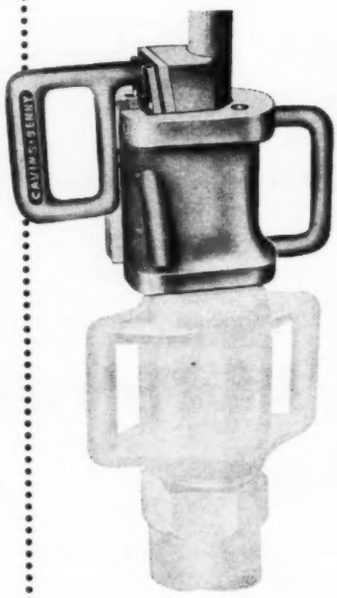
no wrenches
no bolts

SELF-TIGHTENING — Weight of rods pulls wedge into position in body.

SELF-RELEASING— Clamp removed by relieving the load and lifting the wedge.

Adaptable for setting, servicing or permanent installation. 25,000 lbs. A.P.I. rating.



CAVINS

Refer to Composite Catalog or write for Rod Clamp Bulletin

The CAVINS Co.

Main Office and Factory
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• Beaver machines are made with lathe-like precision, yet are as rugged as power shovels. They can be depended upon to "deliver the goods" job after job . . no costly downtime for repairs or adjustments. When you buy a Beaver, you're assured of a quality product, manufactured by an experienced company. That's why we say . . . "Buy a Beaver and forget about it!"

WRITE FOR YOUR BEAVER QUICK-REFERENCE CATALOG NOW!

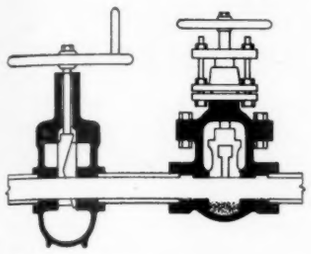
Check these amazing BEAVER Features! The BEAVER Model "A" Pipe and Bolt Machine

• Right-handed operation. • All controls in front. • Chuck to the left, tool mounting to the right. • All gears run in oil. • Inverted chip-free rack-and-pinion feed. • 12-inch working space. • Heavy-duty 1/8 to 2-inch chuck. • Ring-type adjustable quick-opening die heads—no hinge to get fouled with chips. • Power to thread up to 12-inch pipe. • 200 different kinds and sizes of dies available!

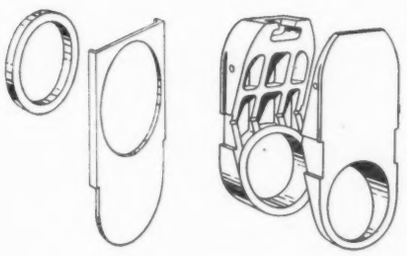
BEAVER PIPE TOOLS
264-300 Dana Ave., Warren, Ohio, U.S.A.
"53 Years of Highest Quality"

12 Reasons

why WKM Valves are your best buy for any service

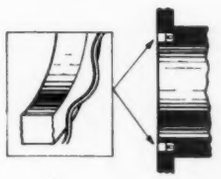


1 **Through Conduit Design** . . . prevents foreign matter from jamming valve, provides smooth, turbulence-free flow, eliminates conventional pressure drop.



2 **Renewable Seats** . . . one- and two-piece seat and skirt assemblies are easily renewable, even while the valve is on the line.

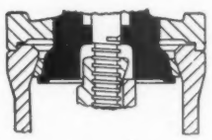
3 **Chrome Plated Gates** . . . W-K-M gates are ground and chrome-plated for a smooth, hard finish. Gates with inlaid seats or made of special alloys are available.



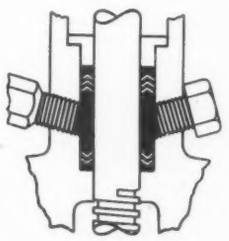
4 **Spring-Loaded Seal & Wiper Rings** . . . bear against the gate and segment at both seats wiping the gate surfaces clean at each operation and also serve to prevent loss of lubricant in operation.

5 **Superfinished Stems** . . . with ground threads for easy handwheel operation even under high packing pressure.

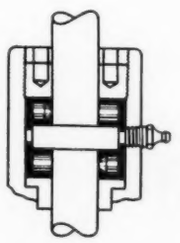
6 **Parallel Expanding Gates** . . . are the basic secret of W-K-M Valves' success. This design, developed by W-K-M, makes possible full conduit flow, positive shut off on both sides and most of the other advantages shown on this page.



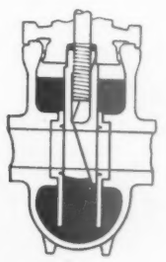
7 **Pressure Seal Bonnet** . . . eliminates bonnet flanges and studs, self-adjusts to temperature changes and seals tighter as the pressure goes up.



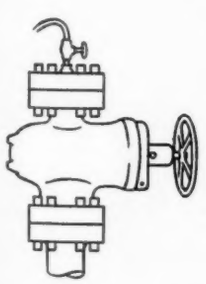
8 **Combination Plastic and Chevron Packing** . . . requires no gland or follower and keeps the packing within the stem enclosure free from dirt and contamination.



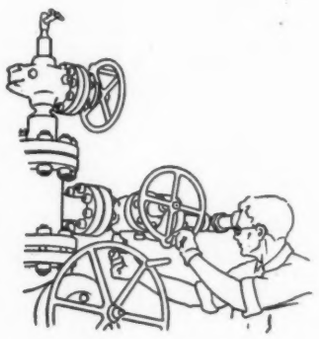
9 **Double Row Thrust Bearings** . . . take opening and closing thrust thus contributing to the easy opening and closing of W-K-M Valves.



10 **Automatic Lubrication** . . . is provided by filling body cavity with grease. Often this amount of grease is a lifetime supply.



11 **Careful Testing** . . . in the shop assures perfect performance in the field. Standard A.P.I. test procedure is used.



12 **Easy Field Repair** . . . while on the line. The entire valve may be overhauled while on the line with pressure off. Stems or bonnets may be replaced while valve is under pressure, if necessary.

No other standard valve offers so many features so important to trouble-free operation. If you need special-service valves, this basic valve is offered plus added features such as teflon seats, super-fast operators and special trim for any service.

To be sure of the very best in valve performance, order W-K-M Valves for every purpose.

W-K-M Valves

W-K-M COMPANY

P. O. Box 2117, Houston 1, Texas
Los Angeles, California
Export Office: 30 Rockefeller Plaza, New York, N. Y.

XUM

Hydro-test found it!

Because of possible damage in handling, many production men now know it pays to Hydro-Test NEW as well as old tubing. Only Hydro-Test checks threads, couplings and the body of the pipe in their made-up position. It takes only 45 seconds, or less, per test (repairs extra) while your regular crew is running the tubing back in the well.

Compare this small amount of test time against the time and cost of another pulling job . . . and your satisfaction in knowing that the pump and entire string, in its made-up position just does NOT have a leak.

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OKLAHOMA CITY
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Hydra-Test, Inc. Phones: OL 1811, MI 9-2206
Units available from Kilgore & Alice, Tex. & Lafayette, La.
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Hydro-Test of West Texas: Phone: 6-4182
WICHITA FALLS, TEXAS
The Portable Pipe Service Co. Phone: 3-2697
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McAdams Pipe & Supply Co. Phone: 4342

Hydro-Test

HYDRO-TEST, INC.
1905 EAST 27th STREET, LONG BEACH 6, CALIF.
PHONE: 404-466

Running Tour

▸ **C. J. Kerwin** and **John H. Douma** received increased responsibilitiles with a new alignment of Sunray Oil Corporation general office production department personnel. Kerwin becomes superintendent of production, and Douma manager of engineering for the production department.

Kerwin and Douma have heretofore shared responsibilities as superintendents of production for Sunray.

In the new alignment within Sunray's engineering section of the production department, **Dr. C. W. Ziemer** will be chief reservoir engineer. **M. S. Patton, Jr.,** has been named chief development engineer. **John D. Gassett** will continue in charge of the proration section, and **Frank C. Folger, Jr.,** in charge of the company's unitization section.

▸ **W. A. Watson,** Humble Oil and Refining Company, assistant district superintendent, Snyder district, West Texas division, has been promoted to district superintendent at Pampa.

C. C. McNeil, assistant district superintendent, Means district, West Texas, was transferred to the Talco district, East Texas division, as assistant district superintendent. **G. E. Ford,** Humble farm boss, Athens district, will replace McNeil.

E. H. Gallencamp, district civil engineer, Stratton district, Southwest Texas division, was transferred to the gas construction division, Houston office, as senior civil engineer. **J. H. Pittman,** senior civil engineer, gas construction division, Houston office, was moved to the Gulf Coast division, as civil engineer. **J. R. Doyle,** Humble rotary helper, Kelsey district, Southwest Texas division, was transferred to the Gulf Coast division office as head chairman.

Royal Lowery, part-time rotary driller, Grand Isle district, Louisiana division, was promoted to full-time morning tour driller there. **Ben DuBose,** part-time rotary driller, Goose Creek district, Gulf Coast division, was promoted to full-time morning tour driller, Stratton district in Southwest Texas.

Ben Seibold, roustabout gangpusher, Pampa district, North Texas division, was promoted to farm boss at the Vernon district. **Henry C. Thomas,** roustabout gangpusher, Athens district, East Texas division, was promoted to farm boss at Athens.

James D. Marshall, Humble senior district clerk, London district, was promoted to assistant district chief clerk at Athens.

▸ **John O. Ely,** senior research technologist, Magnolia Petroleum Company's Field Research Laboratories, Dallas, Texas, was named winner of Socony-Vacuum's 1954 Incentive Fellowship. Magnolia is the southwestern affiliate of Socony-Vacuum.

▸ **Roy A. Kropp,** chairman and president of Kropp Forge Company, Chicago, has been elected to the board of directors of Transcontinental Oil Corporation, Dallas, Texas oil producing firm.

▸ **C. H. Griffin,** R. L. Manning, Inc., Denver, and **S. J. Lintzenich,** Hughes Tool Company, and **J. Howard Barnett,** consulting engineer, both of Casper, were presented the American Petroleum Institute's Rocky Mountain district's "Citation for Service" in recognition of outstanding contributions to district activities.

▸ **Edward A. Koester,** consulting geologist, Wichita, Kansas, has been named president of the American Association of Petroleum Geologists. Other officers are: **Graham B. Moody,** chief reserves engineer, Standard of California, vice president; **Elliott H. Powers,** vice president, exploration, Southern Production Company, Fort Worth, secretary-treasurer, and **Armand J. Eardley,** chairman of the division of earth sciences at the University of Utah, editor.

▸ **Thomas R. Shugart,** geophysical consultant of Dallas, Texas, has been named president of Research, Inc., Dallas. Previously, he was president of Texana Exploration Company, and an executive of Geotechnical Corporation.

▸ **Dr. Samuel Epstein** of the division of the geological sciences at the California Institute of Technology has been promoted to associate professor of geochemistry by the Institute Board of Trustees. His promotion from senior research fellow is effective July 1.

▸ **James D. Stahl,** an engineer with Union Producing Company for the last 13 years, has been promoted to district petroleum engineer. He went to work for Union Producing in 1941.

▸ **A. S. Rhea** has been superintendent of the operating department for Sun Oil Company's southwest division, succeeding **John A. Ritter,** who is retiring after 30 years.

Ritter has been active in API almost since its inception. In 1950 he was presented a certificate of appreciation for his distinguished service and constructive leadership by the Institute.

F. G. (Gus) Prutzman assumes Rhea's former duties and the title of division petroleum engineer. He has been assistant chief petroleum engineer.

Herbert Parker, former assistant chief geologist, has been promoted to chief geologist for Sun's Gulf Coast division. As division chief geologist, Parker assumes duties formerly held by **K. V. Schroeder.** Schroeder, who formerly was both chief geologist and manager of the land department, still is land department manager.

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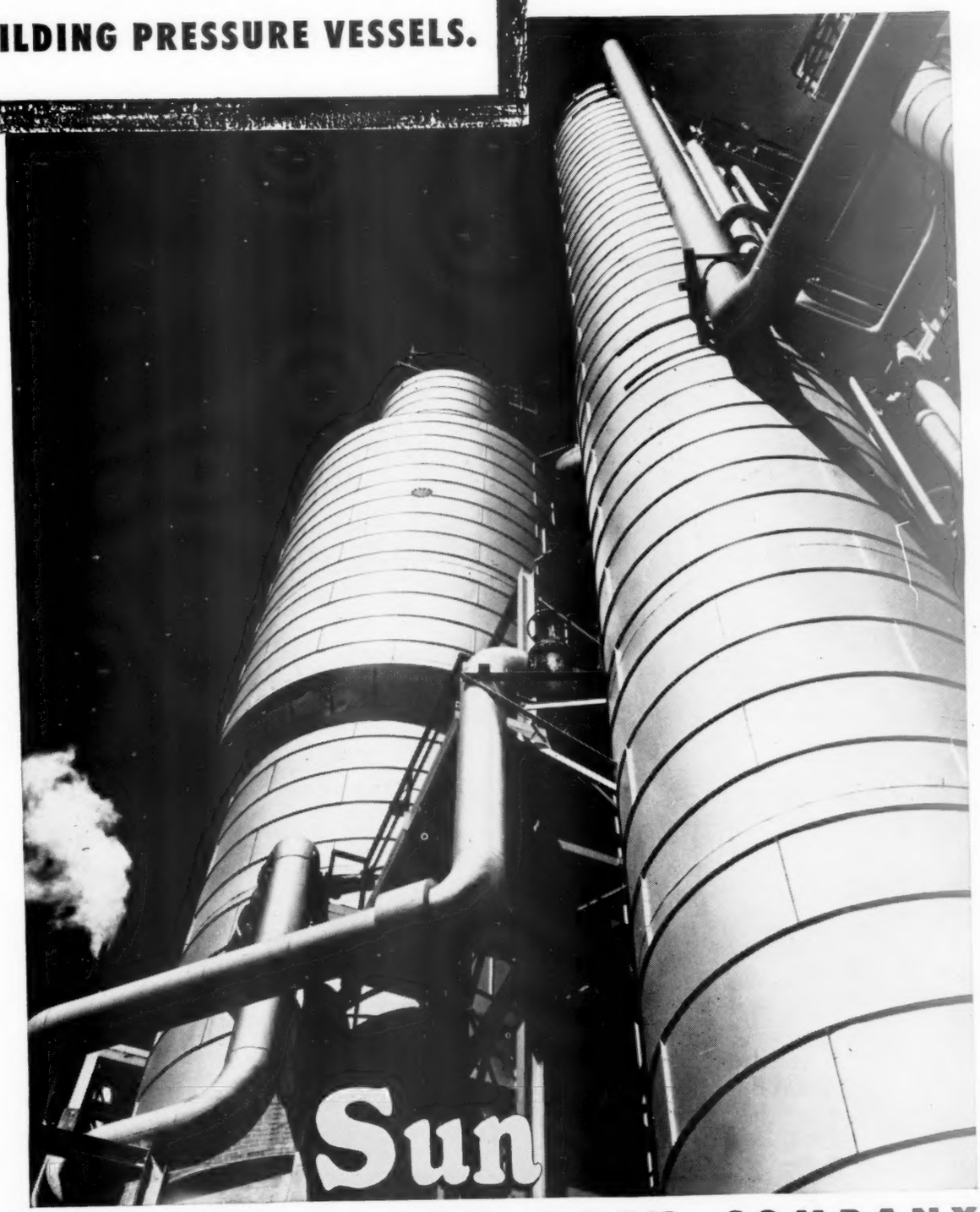
Monuments

TO SUN SHIP'S ACHIEVEMENTS IN BUILDING PRESSURE VESSELS.



SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

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25 BROADWAY • NEW YORK CITY

Sound Selling vs. Smart Talk

Today, essentially, all of the chemical companies have established technical service and sales-supporting technical work. One corporation has 25 laboratories devoted to this type of work supported by 29 field laboratories. The total investment by the industry in such facilities, must run well into the tens of millions of dollars, which is one measure of how importantly the industry regards the sales function.

It is now estimated that 70% of the average chemical company's sales staff is technically trained compared with probably less than 25% only 20 years ago and an insignificant percentage 30 years ago. This current mode of selling is epitomized in the slogan of one chemical manufacturer, namely, "Serving Industry through Practical Applied Science."

From an article: "Selling . . . Its Importance in the Chemical Industry," by J. Warren Kinsman, Vice-President, E. I. du Pont de Nemours & Co., Wilmington, Del., in Chemical Engineering Progress.

Nalco appreciates the use of its slogan, "Serving Industry through Practical Applied Science", as an example of the modern approach to chemical sales. 100% of Nalco's field service representatives are technically trained to help industry make full practical use of the chemicals and methods developed by the Nalco Laboratories: Water, Microbiological, Physical Chemistry, Organic Chemistry, Corrosion, Micrography, Metallographic, Experimental Boiler, Combustion, Oil Treatment, Paper, Ion Exchange, Weed Control, Production Control.

NATIONAL ALUMINATE CORPORATION

6212 West 66th Place • Chicago 38, Illinois

In Canada: Alchem Limited, Burlington, Ontario

THE Nalco® SYSTEM . . . Serving Industry through Practical Applied Science

High Tariffs

In the face of howling screams — by foreigners and Socialists mostly — against America's "prohibitively high tariffs," comes the facts that only seven small nations — and no large nations — have tariff rates, on chemicals and otherwise, lower than in these United States. So says Dr. Cary R. Wagner, twice-president of the Synthetic Organic Chemical Manufacturers Association, speaking to Hudson-Mohawk Council on World Affairs. And these facts come from the results of a complete survey of all the facts regarding tariffs, worldwide and overall.

Even on dutiable goods, our average tariff is only 12.5 per cent, Wagner says — more than half our total U. S. imports enter this country duty-free. The great mass of Europeans, and all those behind the Iron Curtain, believe that people outside this country have no chance to recover from poverty because our tariffs are so high they cannot sell here the goods they make at home. American researchers receive an average of $5700 per year. A non-technical worker receives $1.86 per hour in the USA, while the same one in France gets $0.32 per hour, Italy, $0.30, England, $0.48 and Germany $0.38.

★ ★ ★

Design Courses Offered

An intensive course in "Design of Distillation and Absorption Equipment" will be given July 12 to 23, 1954, at the University of Michigan, by Dr. R. H. Newton, Badger Manufacturing Company, and Professors Brymer Williams and R. R. White of the University staff. Intended for practicing engineers, the course will deal with fundamental principles of trays, hydraulics, azeotropic, and extractive distillation, and allied subjects.

Write Chemical & Metallurgical Engineering Department, 2028 East Engineering Building, Ann Arbor, Michigan.

★ ★ ★

Management Needs Help

Management is in dire need of help, according to Monsanto's F. J. Curtis. Executives appear to work at times in inefficient and unhealthy madhouses, plagued by interruptions, delays, and worries that bring on exhaustion and premature collapse. But the corporations do not appear too worried over this maltreatment of valuable, painfully and lengthily developed national resource, said Curtis at the ACS meeting in Kansas.

His suggested cure is a trident attack: Kill management's worries by telling him how he stands with the company and free his spirit from the undue worries of the unknown. Insist that management have yearly physical examinations. And, enforce vacations. EBB.

★ ★ ★

Buys Company Stock

Champlin Refining Company and its subsidiary, Peppers Refining Company, were sold recently to Chicago Corporation, Chicago, for $55,000,000, Chicago president Richard Wagner has announced. The two refineries will operate as wholly-owned subsidiaries. Earl Baldridge, executive vice president of Chicago Corporation becomes president of Champlin, replacing retiring president Joe M. Champlin, son of the founder of that company. Charles Peppers remains as Peppers Company president, of which Baldridge becomes board chairman, with Richard Wagner chairman of Champlin.

★ ★ ★

Magic Carburetors

Three quite common myths received a rude shock recently through initiative of Sun Oil's investigation of the 200-plus mile per gallon carburetor. Carburetion, says one myth, can triple the miles per gallon of gasoline. Patents can be suppressed and oil and automotive companies try to suppress such inventions, run other myths.

For its pinpricking, Sun chose rumored 200-mile-per-gallon carburetor invented by Charles N. Pogue of Montreal. Questioned on his carburetor, patented in 1936, Pogue said he never made the 200 mile per gallon claims, and tried to stop rumors. EBB.

★ ★ ★

Acetylene Plant

General Aniline & Film Corporation, that "Stormy Petrel" of the chemistry industry and much belabored by legal actions, will build an acetylene-derivatives plant in Calvert City, Kentucky. Lummus Company, New York will build. National Carbide will supply the acetylene; will make mono and di-alcohols, pyrollidones, vinyl alkyl esters and ethers. Cost of plant, $6,000,000.

Hydro-Finishing Unit

A 2000-bbl-per-day lubricating oil unit for Imperial's Edmonton, Alberta, refinery has been contracted for with Canadian Kellogg Company at a cost of $14,000,000.

The new process passes hydrogen through the lubricant fraction during the final refining steps, "to remove impurities and improve lubricating qualities," announcement says. This unit is the first commercial application of the new process, in the world. Construction begins this summer, and is expected to be completed in late '55. It replaces a clay filtration step in lube manufacture.

★ ★ ★

Motor Fuels Rampant

'Improved' gasolines like the famous fictional French detective are "driving off furiously in all directions." First, we believe, was Shell Oil and Continental, with an additive TCP, (tricresyl phosphate) in small amounts added to motor fuels to remove or prevent formation of engine and carburetor deposits and consequent troubles, not a few. Next came Texaco with Petrox. And now Sun, about which Madam Rumor hath it would liquidate its long-term one-fuel policy, brings out a new gasoline that, Sun claims, equals any premium gasoline.

Also, Standard of California whoops it up with a new, detergent motor fuel built especially to eliminate carburetor deposits. The latter, SOCal says, is the biggest single cause of engine repair jobs known; this unnamed detergent either prevents deposits or removes those already formed from "ordinary gasolines," 'tis said with emphasis.

★ ★ ★

Foundation Has Setback

Congress kicked the National Science Foundation severely recently when that body's House allocated $11,000,000 for the next period, or a cool $3,000,000 lower than wanted. Another $3,000,000 of this $11,000,000 is to be given if a corresponding reduction is made in Defense Department basic research support, under plan for said reduction. Appropriations Committee wants Foundation to have more authority in directing research, to reduce or minimize duplication in Federal and private agencies. This is one major purpose of the legislation.

More Ethylene Glycol

Sixteen thousand tons of ethylene oxide, enough to make 20,000 tons of anti-freeze, ethylene glycol, is the capacity of the newly operating unit of the nitrogen division, Allied Chemical and Dye, at Orange, Texas. Presumably the ethylene comes from or will come from Gulf at nearby Port Arthur, which has one huge ethylene plant, and contracted for another. Allied plans eventually to make also such products as polyglycols, ethanolamines—extraction solvent for carbon dioxide and hydrogen sulfide from gases—ethers, etc.

★ ★ ★

British Copolymer Unit

A styrene-butadiene (synthetic rubber) plant for Britain is planned by Monsanto Chemicals, Ltd., subsidiary of the American company. Two British companies, Imperial Chemicals Industries and Dunlop, the latter famous rubber products manufacturer, are also to make rubber-like polymers in the "right little, tight little isle." Monsanto's capacity at first, 4000 tons. Pilot plant is to be operating by summer. Interesting side fact is that Monsanto owns one-third of Forth Chemicals, only British producer of bulk styrene.

★ ★ ★

Electric Via Atomic Power?

The first large-size atomic power plant to produce electric power on a commercial scale is to be built by Duquesne Light and Power Company, Pittsburgh. Cost is $45,000,000, of which Duquesne will pay $5,000,000, AEC the remainder. AEC contracted with Westinghouse to design and build reactor, now well on in design. AEC to get 48-plus cents per million Btu's of steam raised, in first year, upward-sliding scale to 60-plus cents in five years. Will use pressurized water type reactor, a very stable system, "slightly enriched uranium" as "fuel." Capacity is said to be 60,000 kw, minimum.

★ ★ ★

Labor Unions' Value?

Is it because, or in spite of, local labor unions that earnings for refinery workers top their manufacturing brother's weekly wages by more than $22 per week? At any rate, refinery boys are doing well: Their 1953 weekly envelope averaged $93.90. Manufacturing works hit only $71.57. Take-home pay is only part of the success story. Fringe benefits or non-wage payments to petroleum workers are higher than all 20 other industrial categories. Yearly average is just under $1000, according to Bureau of Labor Statistics. Refinery men don't like changes, if one is to use the rate of labor turnover as a yardstick. They like it there and they stay at their jobs. For every *one* that leaves, *four* manufacturing men take off for greener pastures. Under these conditions, should oil workers join the newly proposed Oil and Chemical Workers International Union? E.B.B.

★ ★ ★

Polyethylene Plastic-Plus

A new type polyethylene has been developed and announced by Phillips Petroleum Company. This is a product that offers definite advantages over the older types of polyethylene, claims say. Process operates at below 500 psig, instead of 15,000-30,000 psig and is used with some of the existing processes. Due largely to lower pressures investment cost of this process is considerably lower than cost of older methods.

A semi-commercial plant at the Adams Terminal on the Houston Ship Channel is to be built and a large plant is expected after manufacturers have tested the new product and its possibilities have been evaluated.

★ ★ ★

Ammonia Plant Underway

Brea Chemicals, California, Union Oil subsidiary, has begun its ammonia plant, which will be up to speed, 235 tons per day, in June, its first real output 'Baby.' Now building is its second, a 70 ton per day carbon dioxide, 'dry ice,' etc., plant alongside the ammonia unit. Contracted for is a $2,500,000 nitric acid and ammonium nitrate plant, the first obtained by oxidation of ammonia. Both refrigeration and plant food for the West Coast.

★ ★ ★

Stream Pollution Problems

Pollution of streams is an ever-present chemical plant headache. Now comes irate Shelbyville, Illinois, citizens and opine that National Petrochemicals at Tuscola, 75 miles upstream, is rendering the Kaskaskia River unpotable, foul, dangerous to consumers of its water. The familiar hoopla of a caravan of horn-squawking, shouting, singing population-loaded cars descended on the state capitol at Springfield, and frightened the defenseless (?) legislators into dithers. Company says drought lowered river water level concentrated undesirable solids and solutes therein. The company reported it had lowered oxygen content for a few miles, this to be corrected completely when new aeration unit is operating in June.

Sulfonate Additives

Lithium sulfonates are under intensive study as additives for heavy-duty motor lubricating oils, directed by Foote Mineral Company, large producer of metals and their products, and collaborating with one of the large oil companies. Work is moving out of the "test tube" caliber activity, accenting actual motor tests on the block and on the road, to give the idea the last proof of good or bad results. Product is made beginning with and reacting lithium hydroxide and various sulfonic acids.

★ ★ ★

An Angel Found

Obtaining stock from eight companies that first financed it, Stanolind Oil & Gas Corporation is taking over the property and assets of the gas synthesis plant at Brownsville. Stanolind guarantees that the $17,000,000 RFC loan will be repaid, according to advices received. Ten months' idleness leaves the plant calling for much work and revamping to get it on stream again. New owners also grabbed storage terminal of U. S. I. Chemicals alongside. Most observers want the plant and process to "come through." We'll see. Rumor says Stanolind will spend another $20 million.

★ ★ ★

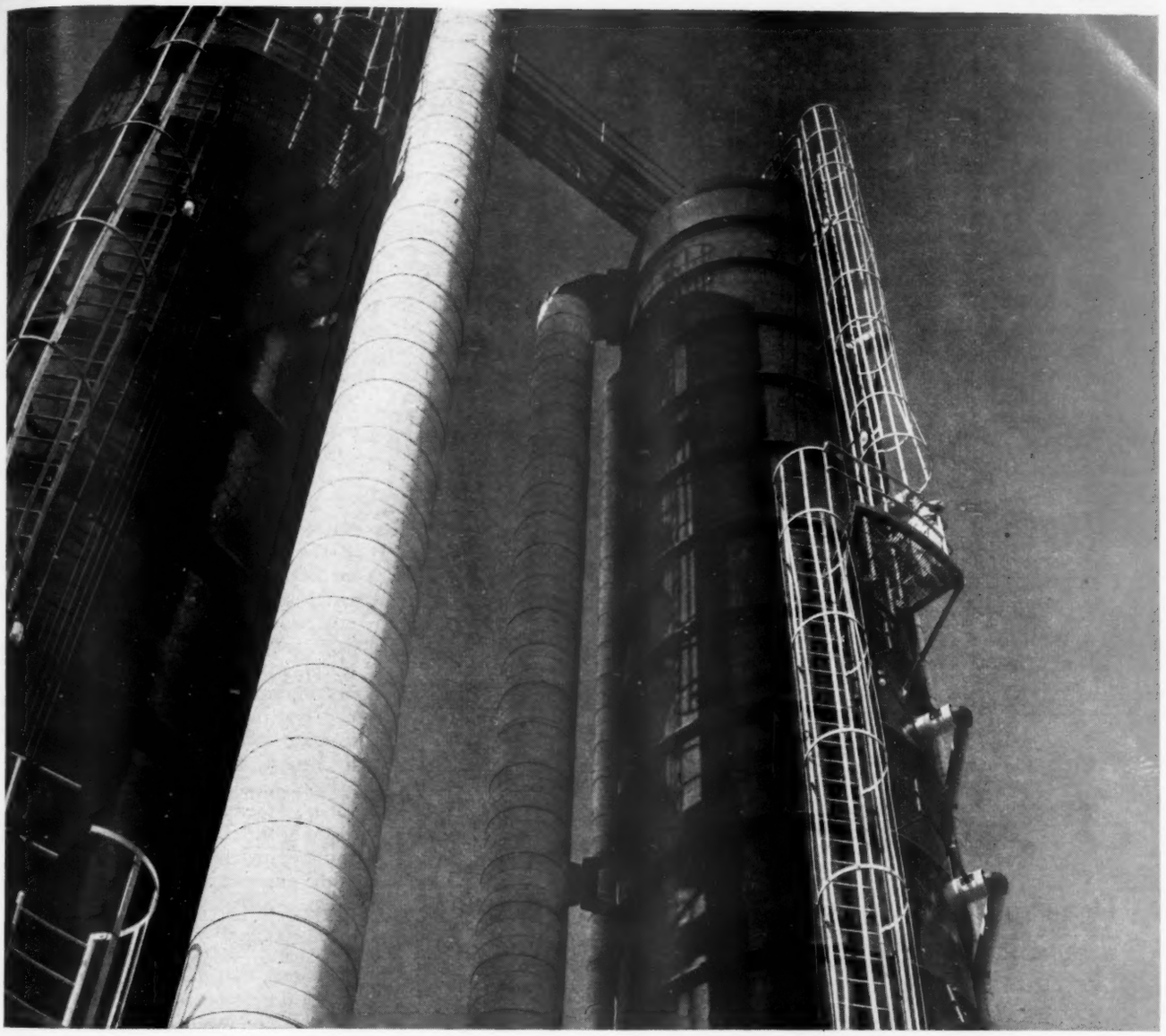
New Platformer for Clark

A new platformer unit is to be built at the Clark Oil and Refining Corporation, which is the former Petco Corporation refinery. Announcement is made by Emory T. Clark, president of the corporation. Company plans to make gasoline with more than 100 octane number rating, to supply its extensive marketing outlets in the Mid-West, Clark stated.

★ ★ ★

Cat Reformer Underway

The new catalytic reformer unit for Pure Oil Company's Heath, Ohio, refinery is going up rapidly, under the direction of M. W. Kellogg Company. The new unit is licensed under the Sinclair-Baker RD-150 catalyst patents, and will reform 33 octane number feed, 3000 bbl per day to improved fuel showing 98 Research octane rating with 3 cc of TEL. The process employs the catalyst that is regeneratable in situ and has a very long catalyst life, it is stated. Containing platinum metal, aromatic products are produced in large yields by this catalyst and process. The Pure unit is expected to go on stream in June, 1954.



Plates and devices employed in towers such as these Dow Chemical columns are all-important in refining and petrochemical manufacture.

Fractionation Brings New, Efficient Designs

No single step in petroleum refining or petrochemical synthesis is of greater importance than fractionation, the concentration of desired fractions into one or more streams. If any one step may be called fundamental, fractionation is that step.

Five of these articles in essentially the form presented before the California Natural Gasoline Association January '54, and one before Natural Gasoline Association of America in April, 1954, give in commendable detail the design, construction, operation, and performance of five new and not-so-new but highly improved tray developments. All these have been tested in both pilot-plant and commercial scale units and have shown, each in its specific manner, the advantages to be obatined by the use of each design. Obviously it is to be expected each design will show certain advantages over all others under certain operating conditions.

EXCLUSIVE

To those interested in advancements in tray design, working always for higher efficiency of fractionation, this symposium constitutes a brief postgraduate course in the essentials of these new developments. These articles are presented to acquaint our readers with the most recent disclosures in this rapidly advancing technology. * *

XUM

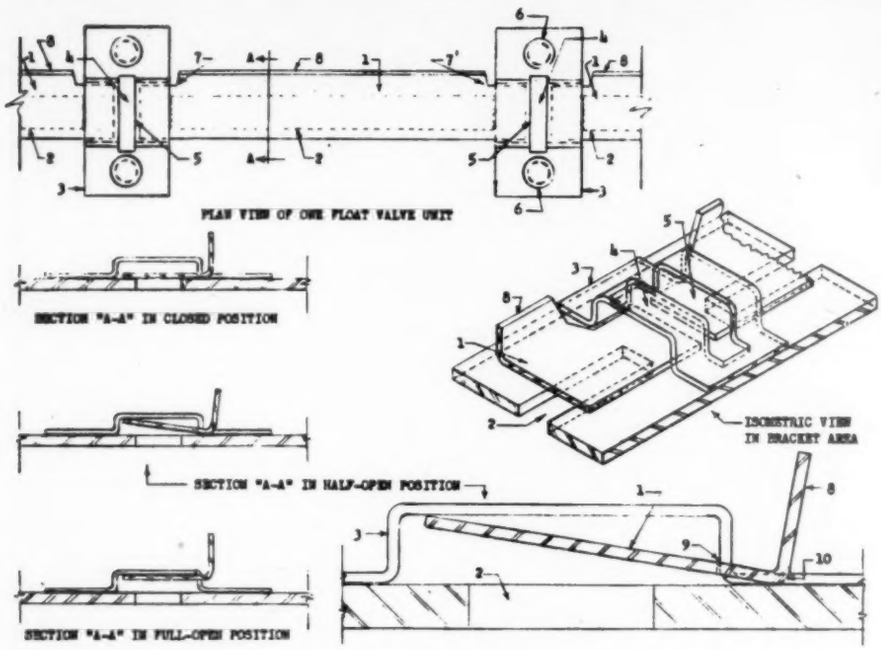

PLAN VIEW OF ONE FLOAT VALVE UNIT
SECTION "A-A" IN CLOSED POSITION
ISOMETRIC VIEW IN BRACKET AREA
SECTION "A-A" IN HALF-OPEN POSITION
SECTION "A-A" IN FULL-OPEN POSITION

FIG. 1. Drawings showing details of construction of float valve assembly.

P 734.51

Float Valve Bubble Trays†

Floating, pivotal valves, of unbalanced weight distribution, introduce a new principle in fractionation

I. EARL NUTTER*

THE name float valve is descriptive of floating pivotal valves that involve a new principle. The valves are heavier on one edge than on the opposite edge and are retained on the tray to limit vertical or horizontal movement. As a contact medium is passed upward through the tray, a floating pivotal movement is attained whereby the light edge of the valve is initially urged away from its seating, over an opening on the tray floor, by pivoting at the heavier edge and finally the heavy edge is urged away from its seating, over the opening on the tray floor, by pivoting at the light edge. Merit of this movement will become evident in the description of operation.

Float Valve

Bubble trays are the result of development and study of bubble tray performance begun in 1945. The purpose stimulating this development was to produce a bubble tray of high capacity with superior efficiency that would also operate with good efficiency at reduced capacity. During the first several years of development, two distinct versions, other than the present equipment, were studied. The first installation of float valve trays was in September, 1951. This installation was in a 6 ft diameter, 16-tray absorber on 24-in. tray spacing operating at about 240 lb absolute pressure equipped for experimental testing and in regular service at a natural gasoline plant in Carson County, Texas.

Construction of Float Valves

Float valves may obviously be constructed in many forms in conformity to this basic principle and, of the many forms investigated, the form described in this article was selected for commercial use because of its simplicity, economy of construction and adaptability to variation in design to satisfy performance requirements. A plan view of one float valve unit, sections of the valve in all limit positions, and an isometric view in the area of the retaining bracket are shown in Fig. 1. Float valves and associated openings in the tray floor are arranged in rows. Retaining brackets at the ends receive corresponding ends of adjacent valves in the same row and the openings in the tray floor extend the full length of span between the bracket edges. The tray deck is solid underneath the brackets to retain the section of deck in a rigid, integral piece and slots are provided centrally across the top of the brackets to permit the escape of gas off the ends of the valves so as to purge, or sweep away, any solids that might accumulate under the brackets and interfere with the movement of the valves. The brackets are positioned transverse and centrally to the tray openings and in standard assembly are secured by two rivets as shown.

The float valves and brackets are made of light gage stainless steel material as a standard. To date all jobs, except one each using 16-gage and 18-gage, have been 20-gage thickness. Referring to the large scale sectional view in conjunction with the plan in Fig. 1, one side of the valve is wider by extending laterally outward intermediate the end sections and turns up to form an L-shaped section. This edge of the valve is therefore the heavy edge because of the offset to one side in width and the upward extending flange, thus; as the opposite, or the light edge of the valve, which raises initially, opens, the offset inner edge of the ends of the heavy side of the valve are raised to or above, the tangent point of the rounded inside corner at the bottom of the sides of the bracket, as the valve pivots about the heel of the L-shaped section of the valve, which is offset and outside in respect to the point of contact between the valve and bracket. This construction permits free movement of the valve in its retaining brackets through all positions and is economical to manufacture.

Operation of the Tray

A photograph of an assembled removable type float valve bubble tray for a 30-in. ID tower is shown in Fig. 2. Float valves are applied to the tray in parallel rows positioned at right angles to the direction of liquid flow across the tray with the light edges facing into the flow. Although other arrangements may be desirable for certain applications, it is believed this arrangement is most generally desirable and is shown in Fig. 3 for a single-flow tray and in Fig. 4 for a double-flow tray. Referring to Fig. 3, all trays utilize the exit weir to seal the base of the entrance liquid downcomer on the opposite side of the tray and downcomer seal weirs are not used adjacent

†Presented before the California Natural Gasoline Association, January 7, 1954.
*Nutter Engineering Co.

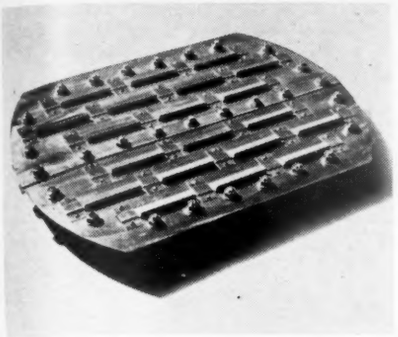


FIG. 2. Assembled removable float valve bubble tray for 30-in. internal diameter tower.

to downcomers. The tower may be fully loaded with either liquid or gas flow initially without interruption or adjustment of either while turning on the other phase.

To describe operation, we shall assume the liquid phase, such as in an absorber, is turned on first. With liquid phase in operation, the liquid flows smoothly across the tray with a minimum of gradient because of practically no obstruction; however, with even a minimum flow, sufficient gradient exists to submerge the valves near the entrance side of the tray in more liquid than on the exit side. Before gas flow is started, a moderate weep prevails through the valves because of imperfections of fit; however, such imperfections of fit are of capillary magnitude and, as the first traces of gas flow starts and sufficient pressure differential is established across the tray to initiate such flow, all weeping in all areas of the tray ceases even with normal liquid flow. Even with maximum liquid flow, the valves remain closed because the weight of liquid downward is always greater than the lateral force of liquid across the tray against the upright web of the valve.

The first small flow of gas brings the light edges of the row of valves adjacent the exit weir into operation. As rate of gas flow increases the light edges of additional rows of valves, consecutively from their exit weir towards the entrance downcomer, are brought into operation. At approximately 20 per cent of design loading of the gas phase, irrespective of liquid loading all the valves throughout the tray are brought into operation and full efficiency of the tray is realized. As rates of flow progress, additional loading occurs through increased differential through the openings of the light edges until at about 40 per cent of design loading the heavy edges begin to rise. Gas emitting from the light sides of the valves urge the ends of the heavy edges of the valve snugly against the inside legs of the brackets and, also the upper edges of the light ends against the top of the inside of the brackets; thus, any movement of the heavy edges is dampened by these contacts. Furthermore, at the time all the light edges of the valves were brought into operation, any previously existing liquid gradient across the tray disappeared; thus, as loading progresses beyond about 40 per cent all the heavy edges of valves

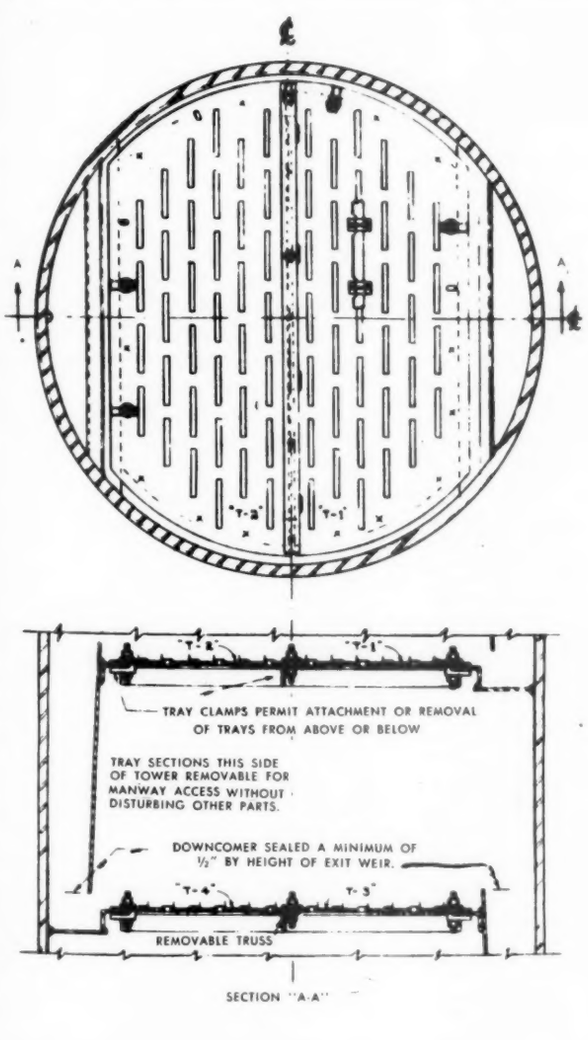

TRAY CLAMPS PERMIT ATTACHMENT OR REMOVAL OF TRAYS FROM ABOVE OR BELOW
TRAY SECTIONS THIS SIDE OF TOWER REMOVABLE FOR MANWAY ACCESS WITHOUT DISTURBING OTHER PARTS.
DOWNCOMER SEALED A MINIMUM OF ½" BY HEIGHT OF EXIT WEIR.
REMOVABLE TRUSS
SECTION "A-A"

FIG. 3. Details of a single-flow float valve bubble tray.

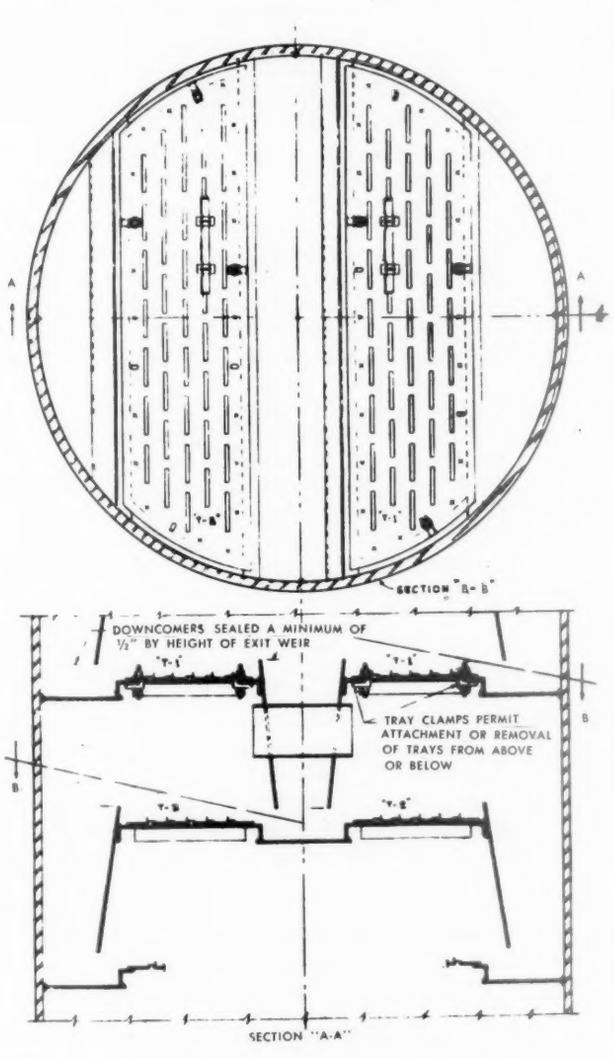

SECTION "B-B"
DOWNCOMERS SEALED A MINIMUM OF ½" BY HEIGHT OF EXIT WEIR
TRAY CLAMPS PERMIT ATTACHMENT OR REMOVAL OF TRAYS FROM ABOVE OR BELOW
SECTION "A-A"

FIG. 4. A double-flow float valve bubble tray.

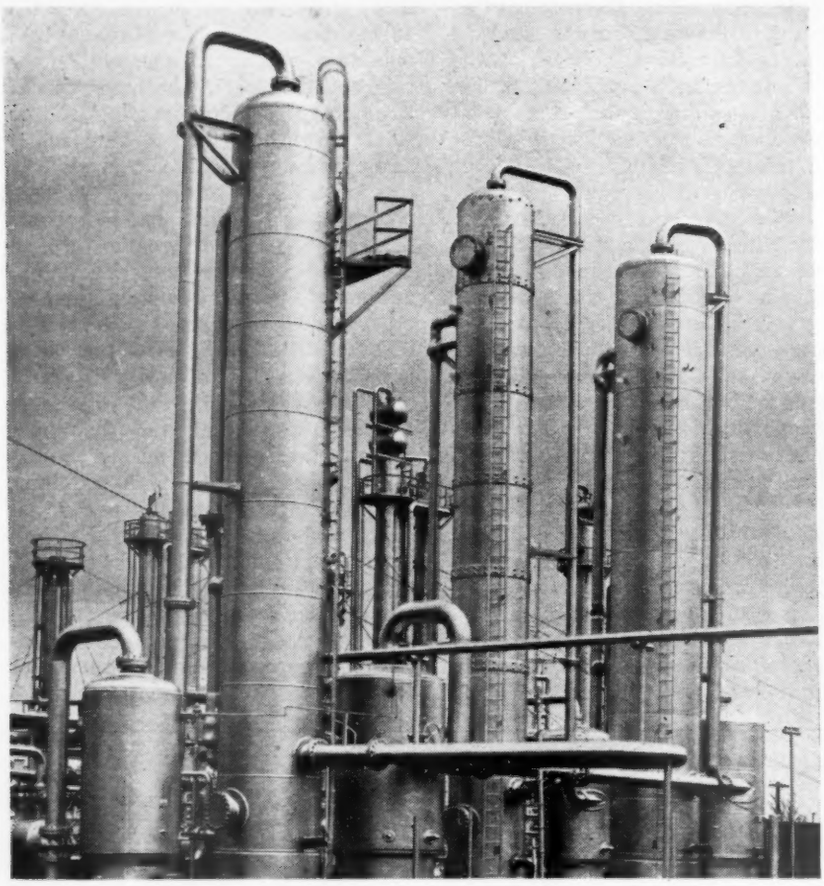


FIG. 5. Left, 70½-inch, 16-tray absorber used for test; two absorbers on right are also equipped with float valve trays.

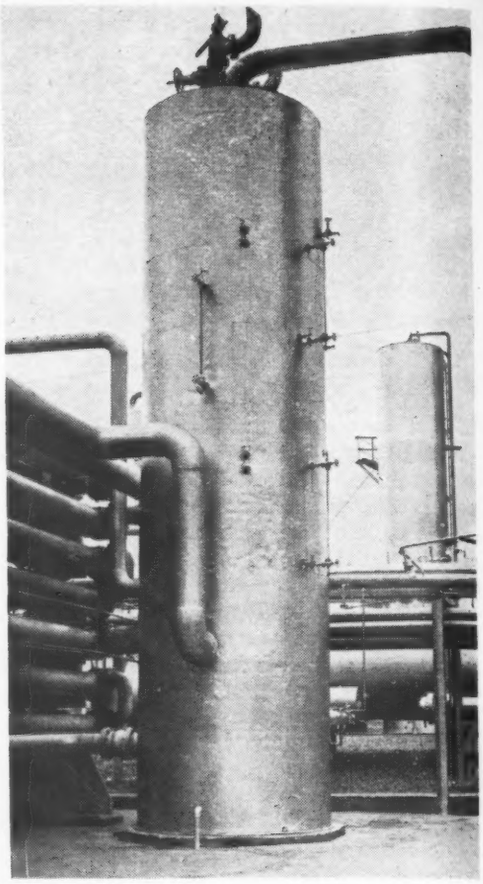


FIG. 6. A 6½-ft, 8-tray still also used in test.

throughout the tray begin opening in unison through their range of movement, and at about 70 per cent of loading all valves are in fully open position. Beyond this point, full loading is accomplished by increased pressure drop through the valves in full open position. The stability of the function of the float valve has been observed during many tests, both on dry valves to develop capacity information and on a single commercial size test tray operating on absorption oil and natural gas. Their stability is also manifest by the perfect condition of trays in a commercial tower observed on inspection after many months of operation.

Test and Operating Performance

Test facilities for measurement of all streams, sampling and observation of temperatures and pressures have been provided on installations in absorption, distillation, and fractionation services.

Absorbers

The first absorber, mentioned earlier, was so equipped for testing and has been tested three different times. On the first test, only 8 trays were used and were installed in the lower 8-tray positions with the absorption oil inlet piped internally for normal entry on the top tray. Later, the top 8 trays were installed and two tests were conducted on the full 16-tray unit. This absorber is the left hand tower in the photograph, Fig. 5. Duplicate samples were carefully taken and analyzed. Observations and evaluations of these tests are shown in Table 1. Although these tests were made with different numbers of trays and at a wide spread in loading, they show the tray performance to be remarkably the same. Operating performance in plants of three different companies in which all of the absorbers were changed over to float valve trays show a reduced fixed gas retention for given product recoveries and in one of these plants, where a still, to be described later, was installed and the oil is completely stripped, there is no pentanes plus content in the outlet gas. In development of the summary results of Table 1, actual per cent recoveries were calculated from the mols of entering gas determined from the analysis and its metered volume divided into the difference between same and the same evaluation of the outlet gas stream. The comparative per cents theoretical recovery were based on an assumed 100 per cent tray efficiency by calculation, using Katz and Hackmuth equilibrium constants for the entering volume and quality of gas at observed conditions. The analysis were somewhat erratic in the cut between iso and normal butanes but, since they are both in the key component range of extraction, they were grouped together for comparison between actual and theoretical recovery. In reference to Table 1, the actual recovery of butanes in the three tests is 98.25, 96.16, and 94.75 per cent respectively, or an average of 96.39 per cent. A similar comparison of the total propane and heavier products is 97.91 per cent average for the three tests. It appears, therefore, that a tray efficiency in the range of 75 per cent is being attained. Similar tests in the same plant on five original absorbers before the changeover gave 14 to 20 per cent efficiency on four of these towers and possibly 30 per cent on one of the towers. In this particular plant, the five absorbers consisted of 2 7-ft diameter 12-tray, 1 7-ft diameter 16-tray, 1 6-ft diameter 16-tray (test tower), and 1 5-ft diameter 16-tray towers, before the changeover to float valve trays. The latter three were equipped with these trays and the 2 7-ft diameter 12-tray towers were removed from absorption service. Although the original towers were more than ample for gas capacity, they were handling about all the oil they would take at an aggregate of 1,250,000 gal daily. The present three towers

appear to be able to handle about 50 per cent more gas loading than originally and are handling 1,785,000 gal of oil daily.

This test absorber has been loaded to full gas capacity which was 51,300 SMCF daily, at which point the tower did not flood but frothed excessively. Upon load reduction of less than 1 per cent, stable operation resulted immediately. A study on the effect of oil rate on gas loading was made and it was found the above gas load could be handled at all oil rates used with identical results. This being the first tower to use float valve trays, the trays were adapted to the existing downcomers and also, this original tray layout was not equipped with nearly so many float valve units as is now standard design. Where this installation carried only 110 valves with 7½ per cent downcomer area, present design permits the use of about 150. Thus, if excessive frothing is the result of slot velocity, then the prospect of appreciable increase in capacity rating is very favorable.

Operating results of the three plants, where float valve trays have replaced the former trays, have in all instances reflected product recoveries at least as good and apparently better than indicated by the above described absorber tests. In all instances, the cross-sectional area of the towers left in service are about 50 per cent of that originally used and, in most instances, the extra towers have been utilized in other services. The present towers at each plant in aggregate are capable of handling more capacity of oil in combination with gas than could be handled with the original equipment.

TABLE 1. Test observations and results on a 6 ft diameter absorber equipped with 8 and 16 float valve trays on 24-in. spacing.

Operating conditions	Test number 1 October 22, 1951	Test number 2 February 22, 1952	Test number 3 April 26, 1952
Number of trays	8	16	16
Inlet gas SMCF/hr.	1,800.08	1,802.93	1,042.48
Outlet gas SMCF/hr.	1,686.68	1,689.19	979.66
Press. lbs abs. base	242.13	233.04	200.84
Press. lbs abs. top	240.73	230.44	199.14
Lean oil gal/hr at 60 F	18,504.40	21,117.62	14,773.48
Temperatures deg F	Gas; In-92 Out-69 Oil; In-.58 Out-.91	Gas; In-81 Out-60 Oil; In-52 Out-83	Gas; In-78 Out-71 Oil; In-64 Out-84
Specific gravities	Gas; In-.696 Out-.656 Lean oil-.8212	Gas; In-.692 Out-.643 Lean oil-.8200	Gas; In-.695 Out-.652 Lean oil-.8100
Mol. wt. of oil	216	216	205
Per cent test recoveries of products as compared to theoretical recovery with assumed 100 per cent tray efficiency.			
Propane	98.77	95.24	113.23
Iso-butane	101.28	112.97	84.10
Normal butane	97.01	90.62	97.76
Butanes grouped	(98.25)	(96.16)	(94.75)
Pentanes plus	96.81	96.88	92.35
Mol. propane plus recovered per hr	97.96	96.05	99.74

Stills

The first installation of float valve trays in a still, or a steam absorption oil stripper in a natural gasoline plant, was made July, 1953. This is a 6-ft 6-in. ID tower with 8 double-flow trays on 24-in tray spacing and replaced two 6-ft O-in. ID towers operating in parallel with 6 single-flow trays each. Fig. 6 is a photograph of this still and Table 2 is a summary of the test data and results showing available comparative data on the two old stills.

This tower was designed to handle 2¼ million gallons of lean oil daily but available oil pump capacity has limited the loading to 1,970,000. A 100 per cent tray efficiency was assumed in design requiring 0.155 lb of steam per gallon of oil at a temperature of 400 degrees F and 55 lb absolute. The results show this performance to be accomplished. The levels of liquid stack-up in the downcomers indicates the tower could easily handle the 2¼ million gallons of circulation at 90 per cent of flood point loading.

This still is handling twice the load per square foot of cross-section and using half the stripping steam in comparison to the old stills. Most important, it is thoroughly stripping the oil, whereas the old stills were leaving an undesirable per cent of saturation in the oil.

Fractionators

The first installation of float valve trays in a fractionator was also made in July, 1953. This is a 4-ft, 6-in. ID de-propanizer with 30 trays on 18-in. tray spacing. The piping was installed so the tower could be operated with the full 30 trays, or could be refluxed and operated on 14, 16, or 18 trays (the regular alternate feed entries) with feed points lowered to alternate points on trays 4, 6, and 8. Fig. 7 is a photograph of this system.

Two tests using 30 trays in one instance and 18 trays in the other have been conducted but because of mechanical trouble and poor measurement, the results are not presented. Time since has not permitted additional testing.

The tower operates extremely smooth and abrupt changes in feed or reflux rates are not reflected on the temperature or pressure recording controller charts. The maximum loading ever placed on the tower was during the 18 tray test when 1085 mol hourly of combined reflux and overhead vapors, representing an 8.63 to 1 reflux ratio, were handled in the fractionation section. At this time the tower was operating at 263 lb absolute pressure and 127 F top temperature. The overhead contained 2.3 per cent iso-butane and the base product 0.90 per cent propane. There was no indication of being close to a flooding load although the liquid in the gage glasses on the downcomers was standing 9 in. above tray deck level, or one-half the distance between trays.

This tower currently operates on 30 trays and as an average with a feed of 3700, base product of 2350, overhead product of 1350 and reflux of 7225 gal hourly. Operating pressure is 263 lb absolute and the top temperature 127 F. The above reflux is a ratio of 5.35 to 1 against the overhead propane production. Frequent control analysis show the propane to contain 1.0 per cent iso-butane and the base product to contain 0.7 per cent propane as an average. These results reflect at least 20 per cent more effective fractionation per tray and capacity than was being accomplished with 2 36-in. ID 30-tray towers operated in parallel in this same service previous to this installation.

Of interest, is a 3-ft, 0-in. ID, 46-

TABLE 2. Summary of test results on a 6½ ft diameter still equipped with 8 double-flow float valve trays on 24-in. spacing and comparative results in part for 2-6 ft diameter stills operated in parallel and replaced by new float valve tray still.

Item	New still	Old stills
Date of test	9/23/53	No actual test
Oil cir. gal/day	1,969,607	1,800,000
Stripping steam lb/day	303,120	552,000
Lbs steam/gal oil	0.1539	0.3065
I.B.P. lean oil deg F	444	360-385
% over at 400 F	0	0.3-0.5
% sat. by CO_2 method	0.26	Not run
Gasoline hydrocarbons passing still — mol/day:		
(a) Liq. feed to de-ethanizer.	8727	No test data
(b) Vapor recycle to de-methanizer	4222	No test data
Reflux oil return from deph., gal/min	30.16	Approx. 60
Press. lbs abs. base	55.2	Not tested
Press. lbs abs. top	54.25	Approx. same
Oil entering deg F	395	403
Oil leaving deg F	387	400
Stripping steam deg F	387	Approx. same
Steam superheat deg F	77	Approx. same
Liquid levels in downcomers above top of entering tray decks. (Exit weirs 1⅞ in. high)		
(a) Above no. 1 tray (bottom tray)	8 in.	No data
(b) Above no. 2 tray	8⅛ in.	No data
(c) Above no. 5 tray (probably error)	7⅝ in.	No data
(d) Above no. 7 tray	8¾ in.	No data
Mol. wt. of oil in system approx	216	210
API of oil in system	40.7	41.5
Mol. wt. of charge (new) oil	180	180
API of charge oil	42	42
Approx. IBP charge oil deg F.	415	415
Approx. EP charge oil deg F.	520	520

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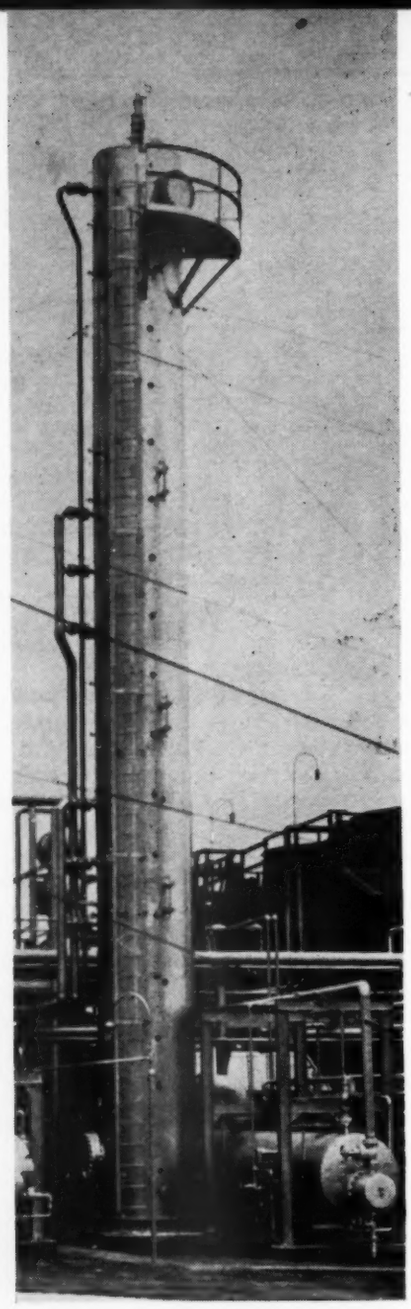

FIG. 7. A 4½ ft diameter 30-tray fractionator employed in the extended test.

tray butane splitter with 21-in. tray spacing put into operation in late October, producing iso-butane with 1.8 per cent normal-butane contamination and normal-butane with 3.2 per cent iso-butane contamination. The reflux ratio to overhead is 23.6 to 1 and represents a vapor load in the fractionation section of tower of 505 mol per hour. The tower operates at 125 lb absolute pressure with a top temperature of 134 F.

In General

Fig. 8 is a photograph of a rich oil de-methanizer stripper and a reabsorber equipped with float valve bubble trays. This stripper is an old 7-ft, 0-in. 12-tray absorber in which the downcomers, of single-flow type, were enlarged when the float valve trays were installed. This tower is handling a rich oil volume of approximately 2,100,000 gal daily, or about 1460 gal per minute. A volume of 1,600,000 cu ft daily of vapor recycle off the raw product accumulator is introduced into the bottom of this tower as a stripping agent. Although no tests have been made on this system, operating results indicate it is more than meeting design requirements.

Commercial Installations

Since the first commercial installation of float valve bubble trays in an absorber in September, 1951, a total of 27 installations have been sold. Twenty of these installations are in service and the others will soon be operating. Of these installations, there are 10 absorbers, 4 re-absorbers, and 2 each of fractionators, stills and rich oil de-methanizers. These sales have been to 11 companies, of which three have made repeat orders. All jobs have fully met performance recommendations and, in most cases, complete satisfaction with performance has been voluntarily expressed.

It is quite evident from the experience factor on these trays that appreciable increased efficiency and capacity has been realized over conventional trays now in general use. These trays are simple and durable in construction, are easy to handle and install, are highly efficient over wide loading ranges and have many merits, several of which are summarized as follows:

1. *Efficiency constant over wide operating range due to uniform distribution of gas and liquid forced by low value pressure differential produced by float valves.*
2. *Energy of gas passing "float valves," in narrow ribbons at tray level utilized for intimate contact.*
3. *Time contact at maximum because of lateral high velocity impingement at tray level.*
4. *Mist and entrainment to tray above at minimum due to uniform blanket of frothy liquid on tray.*
5. *Liquid gradient across tray is at minimum because of no high obstructions on tray floor and, in fact, disappears above 20 per cent loading.*
6. *Liquid cannot short-circuit tray at any operating rate and exit weirs seal downcomers from opposite side of tray.*
7. *Liquid capacity high due to no obstruction at tray entrance and across tray.*
8. *Interruptions of either gas or liquid flow may be restored without adjustment of flow or other medium.*
9. *Fouling is minimized due to active operation throughout tray at all capacities.*
10. *Installation readily applicable to existing towers and downcomers in either removable or fixed tray equipment.*
11. *Light weight yet extremely sturdy and price economical including stainless steel trim.*
12. *Design and engineering simple and positive, thus risk or hazard of improper design eliminated.*

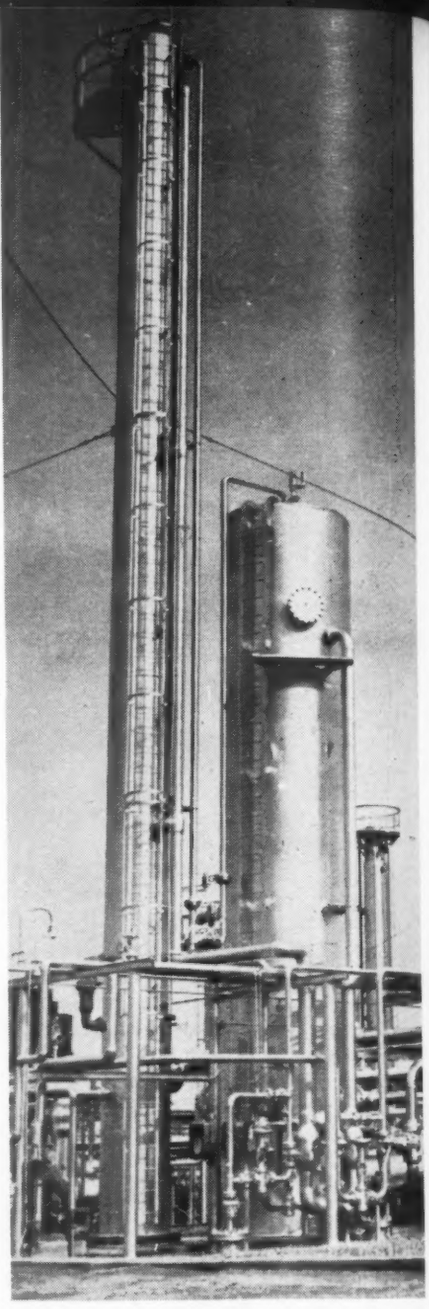

FIG. 8. A 7-ft diameter, 12-tray rich oil demethanizer stripper column, and a 3½-ft diameter 24-tray reabsorber, both equipped with single-flow float valve trays.

A brochure giving more complete information is available on request from Nutter Engineering Company, 1500 Bowie, Amarillo, Texas. * * *

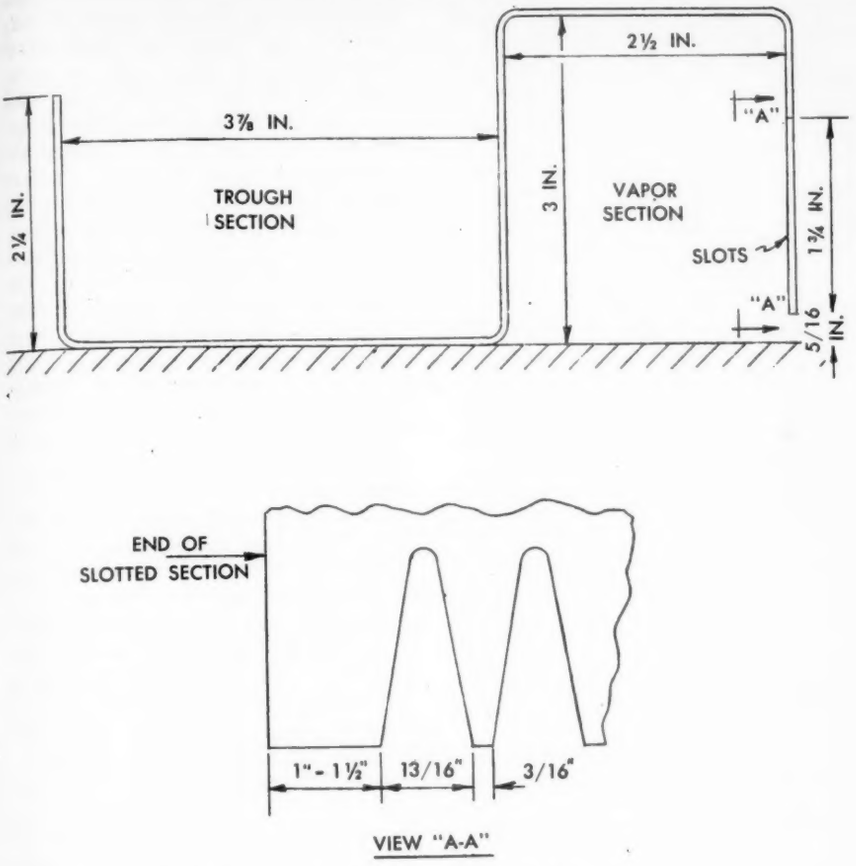

FIG. 1. Typical "S" member design, with slot detail (below).

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Uniflux Fractionating Tray†

Design based on an S-member, including a trough and vapor section tray, has been tested in catalytic cracking service

V. O. BOWLES*

OVER the past two decades the experience of Socony-Vacuum with fractionating trays has been almost exclusively with trays of the bubble cap type. During this period Socony has left the problems of rating and designing trays almost entirely in the hands of engineer-contractors and has made little attempt to develop specifications for, or standardize on bubble cap tray designs. Consequently to protect continuity of operation, it has been necessary to warehouse a great variety of bubble caps and tray parts, with resultant high inventory cost for large stocks that are turned over very slowly.

It has been the experience of Socony that fractionators have been generally operated ultimately at rates substantially in excess of original design rates and only rarely has it been considered expedient to replace, or even significantly alter any trays. Furthermore, the fractionating efficiency of bubble cap trays appears to hold up remarkably well, even at rates 40 per cent to 70 per cent in excess of original design rates. Additionally, experience indicates that the ultimate capacity of bubble cap trays is more often limited by downflow restriction than any other cause. There is some reason to believe that in some fractionators where conditions of high downflow exist, that fractionating efficiency is not all it should be, because of excessive hydraulic gradient and resultant unequal slot submergence.

Although over the years there have been some notable inovations in fractionating tray design, no new or improved design has yet been offered that has received wide general acceptance. Bubble cap trays are still by far the most commonly employed fractionating trays today and probably will be for at least some time to come. This is remarkable when one considers that there has been no such significant improvement in bubble cap trays during the last 15 years that this type of tray can be frabricated and installed more cheaply today than 15 years ago (disregarding the effect of inflation). It is not intended to deny that there have been improvements, because it is recognized that fabricators have bent considerable effort to this end and certainly with some success. On the other hand, it is possible that more stringent requirements and specifications of process designers have tended to nullify such gains.

As have other operators and designers of fractionating equipment devoted considerable attention to the development and improvement of fractionating tray design, so have Socony-Vacuum engineers over the past several years. The result has been the development of the Uniflux fractionating tray. The Socony approach to this problem has been not to develop a radically new and different vapor-liquid contacting device, but to develop a tray employing the same general principles as bubble cap trays which corrects some of the faults in conventional bubble cap tray design and at the same time is simple, adaptable to standardization, and inexpensive.

Socony Uniflux type fractionating trays perform in substantially the same manner and have many of the same characteristics as conventional bubble cap trays. Since the design of these trays combines functional and mechanical features, the tray is light in weight and therefore less expensive than comparable bubble cap trays. It is of simple design and can be rapidly installed in fractionating towers and easily removed if necessary for maintenance inspection and cleaning.

The fundamental unit of the Uniflux tray is an S member (see Fig. 1). The vapor section of each S member is enclosed at each end by vapor closure pieces. Intermediate stiffeners are fastened at specified intervals in the trough section, to insure a good section modulus to the member, especially to the free wall of the trough section. These vapor closure pieces and tray stiffeners are slotted so that on asembly the S members are imbricated as shown in Fig. 2. Thus the basic S member has

†Presented at CNGA, Los Angeles, January, 1954.

*Socony-Vacuum Oil Co., Inc., Refinery Engineering Section.

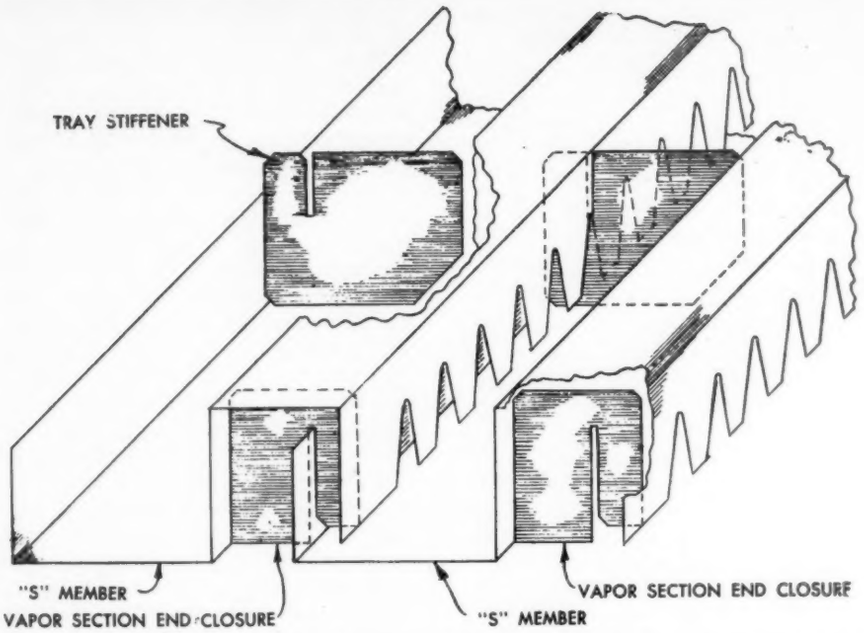

FIG. 2. Graphic view of typical tray sections. "S" members are spaced and fitted together to make up complete tray.

structural, as well as functional properties. When fabricated of 16 gage material, it has ample strength to span a 10 foot diameter tower with negligible deflection under operating and maintenance conditions. In larger towers (up to 20 ft diameter) a single intermediate support beam is used. No other support beams or purlins are required. These S members are secured to conventional support rings by a single conventional tray clamp at each end. The general assembly of a single cross flow Uniflux tray may be seen in Fig. 3. It may be seen that the S members are assembled starting from the trough at the downstream side of the tary. The last vapor section is fastened to the vertical flange which is a part of the segmental section at the foot of the downcomer. For trays having more than 7 S members, a split S member is provided on alternate trays so that vertical access is provided for maintenance, cleaning and inspection. Downcomers are similar to those of conventional bubble cap trays, except that they are standardized with Uniflux trays and are so designed that unrestricted downflow is insured. For trays of very large downflow requirements the vertical flange of the segmental section at the inlet side of the tray is extended upward to provide a proper seal for the downcomer at the inlet to the tray. Double cross flow trays employ the same basic S member elements and are of similar design to the single cross flow design just described.

The tray parts are so proportioned that the available slot area is about 12-14 per cent of the superficial tower area, or generally equivalent to that provided in conventional bubble cap tray designs. Since the slotted sections are well separated, there is no interference of the vapors issuing from one slotted element with those issuing from another and the entire length of the slotted sections is fully effective. Furthermore, the vapors issue forth in one direction and in such a manner as to boost the liquid across the tray and compensate for hydraulic gradient under all conditions of flow. Therefore, running slot submergence is uniform across the tray. Riser area in general averages 2 to 4 times the riser area provided in bubble cap tray designs. Likewise, reversal area and equivalent annular area are large. Therefore, the Uniflux tray is characterized by a lower fixed pressure drop (exclusive of that due to slot submergence) than bubble cap trays. From data developed to date with the Uniflux tray it appears evident that the combination of equal slot submergence (compensated hydraulic gradient), low pressure drop and elimination of areas of interference will result in measurable performance advantages.

Socony Uniflux trays fabricated of 16 gage material, complete with downcomers, weigh about 8 lb per sq ft of superficial tower area. Fabrication is very simple and can be accomplished with standard press brakes, shears and die stamping equipment found in many light metal shops. Thus the Uniflux tray is very inexpensive. Experience in the purchase of a large number of these trays indicates costs in the range of 60 per cent of the cost of conven-

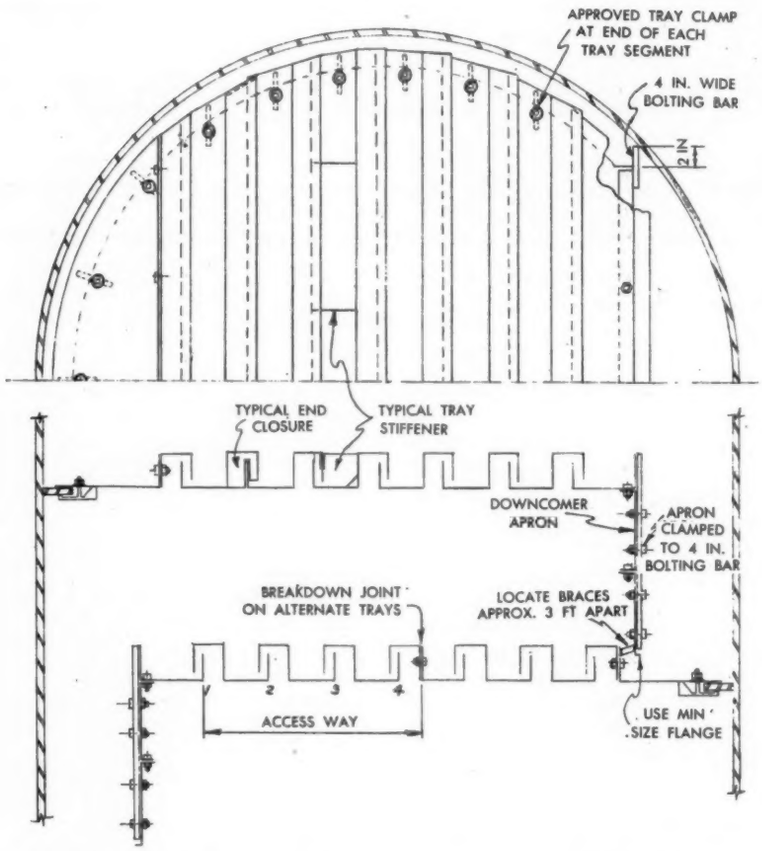

FIG. 3. Plan and elevation drawings of tray assembly, showing bracing and support details.

tional bubble cap trays made of similar alloy.

Uniflux fractionating trays have been in service on catalytic cracking facilities at the refinery of Socony-Vacuum Francaise in southern France. The applications at this refinery include the feed preparation towers, the reactor effluent fractionator and its strippers, the amine absorption system, hydrocarbon absorber, debutanizer and a side stream stripper for recovering butane cut from the debutanizer. This catalytic cracking unit has a capacity of approximately 17,500 bbl per day. The fractionating equipment has performed in a completely satisfactory manner from the start. While fractionation is considered to have exceeded expectations, it would be premature to attach any quantative efficiency or capacity advantage on the basis of the data that have been secured to date. The management in France is especially impressed by the low cost of installation of these trays and by the very low maintenance requirement since operations started.

In the United States design development has been underway in cooperation with tray fabricators, aimed largely at the developing of a uniform set of specifications for the Socony Uniflux fractionating tray. At the present time Uniflux fractionating trays are being planned for more than 130 fractionating tower installations in the United States and abroad, including the entire fractionating tray requirements for three complete refineries. Within a few months it is expected that a sufficient amount of reliable information will be available to more quantatively assess the anticipated performance advantages of the Uniflux fractionating tray. In the meantime, Socony-Vacuum has taken the position that these trays are extraordinarily inexpensive and that on the basis of merely equivalent performance very substantial savings in capital outlay have been realized.

The problem of warehousing spare parts for Socony Uniflux trays is quite simple and very inexpensive. For example, if Uniflux trays are being used in an entire new refinery, it is merely necessary to have on hand an appropriate number of S members approximately 10 feet long and a suitable supply of vapor closure pieces and tray stiffeners. A suitable stock of 16 gage flat plate can be provided for downcomer aprons, seal pans and other miscellaneous tray parts.

Consistent with Socony-Vacuum policy the Uniflux fractionating tray is being made available to the petroleum and chemical industry on the basis of a modest fee of $1 per square foot of superficial tower area per tray. In actual practice fabricators will be licensed to construct Socony Uniflux fractionating trays and this fee will be included in the tray quotation by the fabricator. At the present time six fabricators of fractionating trays are in a position to furnish quotations in the United States and one fabricator in France. The information necessary for fabricators to build these trays will be made available to other firms on request. Rating of trays will be provided by the Refinery Engineering Division of Socony-Vacuum Oil Company, at the request of either engineer contractors or the ultimate users. Such requests are usually processed in a matter of a few days, even though they might include the entire tray requirements for a complete processing unit, or an entire refinery. * * *

P 734.51

Performance of Bubble Cap Trays†

Sizes and dimensions for four bubble cap columns, to meet four sets of specifications, are presented in this article

RALPH M. YOUNG*

THE subject of fractionation has been of direct concern to C. F. Braun and Company for the last 30 years. We have studied, engineered, and installed a great variety of fractionation-devices during this time. One of the oldest of these devices is the bubble cap tray. This paper gives some of the interesting highlights of our work on the performance of bubble cap trays.

The petroleum industry has used bubble cap trays for the past 34 years. This continuing popularity is due to three things. Columns equipped with bubble cap trays can handle a wide variety of feedstocks. They give good

†Presented at the California Natural Gasoline Association Symposium on Fractionation Columns, held in January 1954.

*C. F. Braun and Company, Alhambra, California.

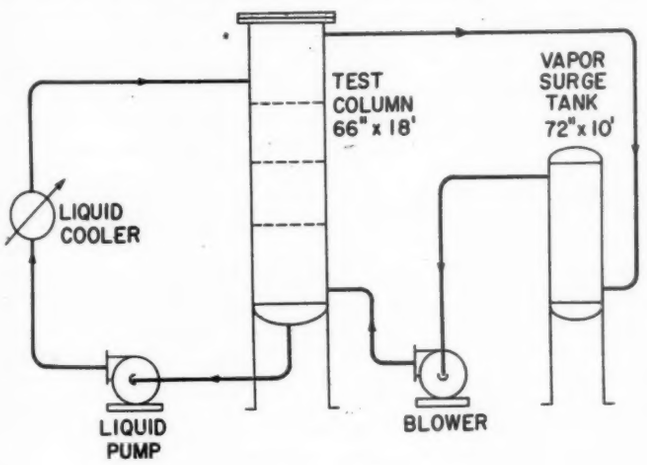

FIG. 1. Schematic flow diagram of column capacity test unit.

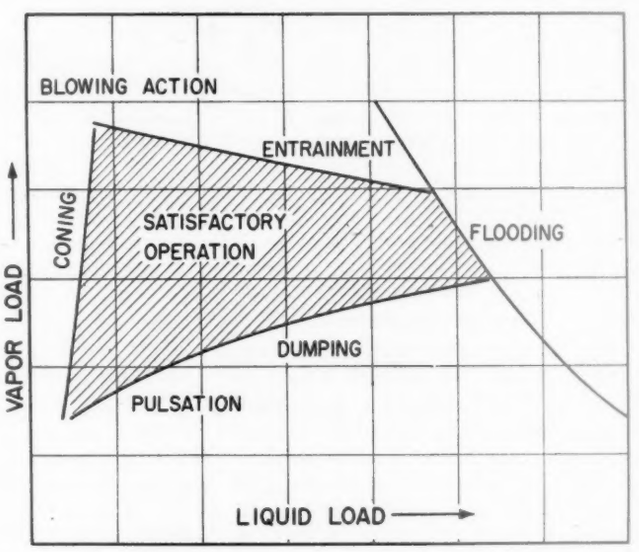

FIG. 3. Satisfactory operation area in capacity-graph of tray action.

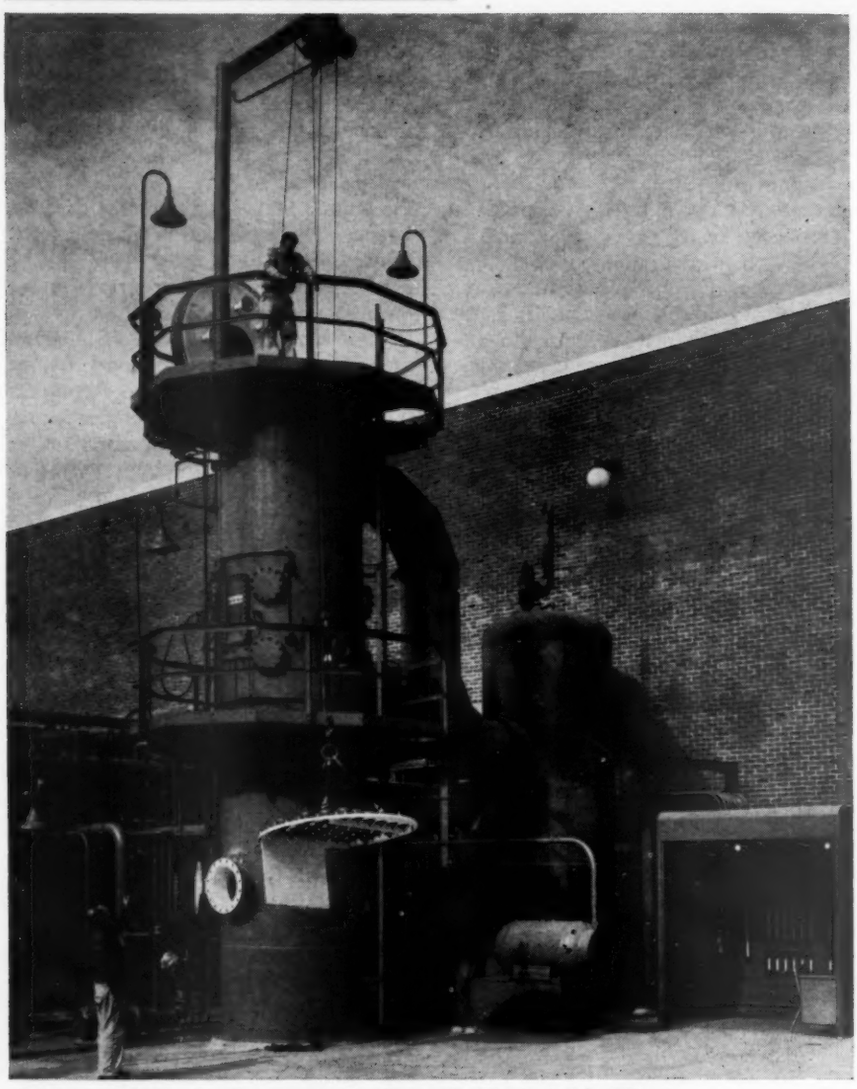

FIG. 2. Photo of column-capacity test unit, illustrated in Fig. 1.

performance over wide ranges of liquid and vapor-loads. And they have relatively low maintenance-cost.

Early use of the bubble cap tray was in such applications as the separation of crude oil into gasoline, naphtha, kerosine, and so on. In these early applications, very little in the way of fractionation was required. And comparatively little development-work was done on bubble cap tray design. In recent years, however, rigid product specifications and rising capital costs have required much development work to be carried out, both by the petroleum industry and by engineering companies such as ours.

Test Equipment

The research carried out in the laboratory from 1925 to 1950 was done on partial-tray sections or single trays using air and water. Additional studies were made on commercial columns in the field. As a result of these studies, we came to the conclusion that data so obtained are much too limited in application. We decided to continue our research program with a commercial-size test unit capable of supplying a wide range of data.

Fig. 1 shows a schematic diagram of the test unit. The principal pieces of equipment are (1) a 66-in. test-column, 18 ft head-seam to head-seam. (2) A vapor-surge tank which is 72 in. in diameter and some 10-ft high. (3) A 150-hp blower for circulating vapor. (4) A 15-hp pump for circulating liquid. And (5) a liquid-cooler.

In operation, vapor passes from the top of the column into the surge-tank where liquid droplets are settled out. The vapors then flow through an orifice-run and back to the suction-side of the blower. The liquid is circulated from the bottom of the column, through a liquid-cooler, and to the top tray. The liquid-cooler maintains constant-temperature conditions in the column.

The unit is designed to operate over a wide range of liquid and vapor rates. The maximum liquid rate is some 550 gal per minute, and the top vapor rate is 16,000 cu ft per minute. In addition, we can make studies with a wide variety of hydrocarbon test-systems.

For studies on bubble cap trays, the column normally contains three trays. These trays are fully equipped for all kinds of measurements—pressure-drop, hydraulic gradient, entrainment, liquid-level in downpipe, and so on. In addition, the column is equipped with windows on the sides and on the top to permit visual and photographic studies.

Fig. 2 shows a picture of the test-unit taken during the installation of test-trays.

Performance Factors

In discussing the factors that influence the performance of bubble cap trays, we find it convenient to think in terms of a capacity-graph, shown in Fig. 3. We plot vapor-rate as ordinate, and liquid-rate as the abscissa. The region of satisfactory operation is shown as a cross-hatched island, bounded by some six conditions that limit satisfactory performance. Pulsation, dumping, coning, blowing, entrainment, and flooding.

Pulsation. Pulsation occurs when the amount of vapor passing through a tray is so small that the caps pass vapor intermittently. The intermittent vapor-flow causes a pulsating condition on the tray and results in poor vapor-liquid contacting. A secondary effect is that between surges of vapor through the caps, liquid dumps through the cap-riser to the tray below. This short circuiting of the liquid further decreases the tray-efficiency. Our tests show that the point at which a bubble cap tray pulsates is influenced by three things. Cap-size. Slot-area. And properties of the hydrocarbon-system.

Dumping. Dumping results at relatively high liquid-loads when some of the upstream caps do not pass vapor. Liquid dumps through the risers of the caps that are not operating, and decreases the tray-efficiency.

Heretofore, a widely accepted view has been that dumping is caused by hydraulic gradient. That is, when the hydraulic gradient above a row of caps exceeds the pressure-drop through the caps, the caps stop bubbling and liquid will dump through the risers to the tray below. We find that hydraulic gradient has little effect on dumping.

The major cause of dumping is the kinetic-energy in the liquid-stream as it leaves the downpipe and enters the tray. When the energy in this stream is greater than the vapor driving-force across the caps, the liquid will dump to the tray below. These conclusions are based on tests of several types of tray-layouts, using different numbers of cap rows, and a variety of hydrocarbon test-systems.

We have found that an inlet-dam upstream of the first row of caps, prevents liquid from impinging on the caps and reduces the amount of vapor required to prevent dumping. In many

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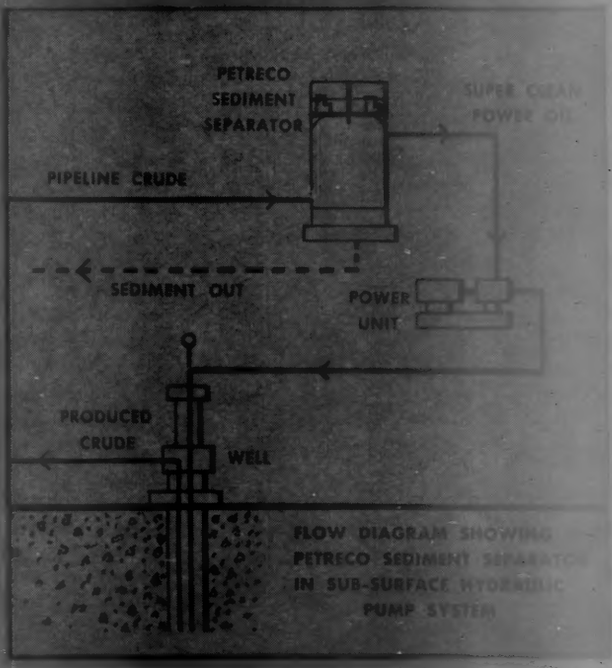

FLOW DIAGRAM SHOWING PETRECO SEDIMENT SEPARATOR IN SUB-SURFACE HYDRAULIC PUMP SYSTEM

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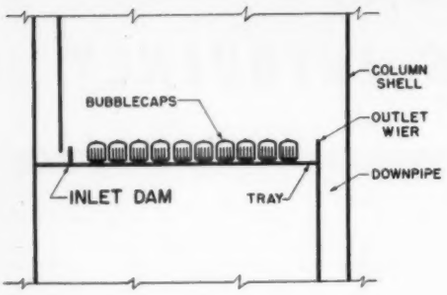


FIG. 4. Detail of use of inlet dam, on a bubble cap tray.

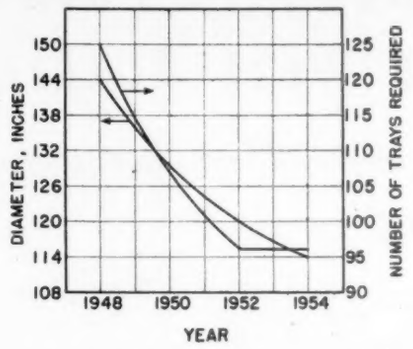


FIG. 5. Chart showing improvement in design of typical fractionator over a 6-year period; both column diameter and number of trays has diminished steadily.

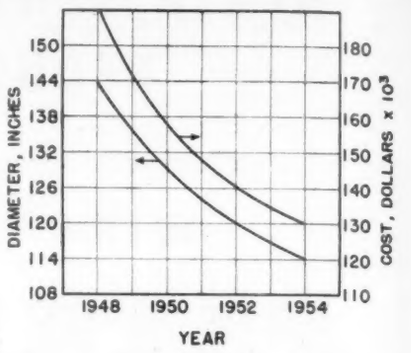


FIG. 6. Cost-Size-Time graph, corresponding to the curves in Fig. 5, for column to give required performance as a cyclohexane fractionator.

cases, is is actually impossible to make a tray dump, when using a properly designed inlet-dam. This is a new application of a rather old device, as shown in Fig. 4.

The location and height of the inlet-dam must be given careful consideration for a given service. If these two factors are not considered, the use of the dam can cause a poor distribution of liquid, and can decrease the capacity of the column.

Tray-Stability. The vapor rate needed to cause all caps on a tray to bubble is often higher than that needed to prevent dumping. And since we are interested in getting good vapor-liquid contacting, we design for vapor rates that bring all of the caps into action. When this condition exists, we say that the tray is stable.

Coning. The third factor that limits satisfactory performance is coning. Coning takes place when the combination of weir-height and the liquid-crest over the weir does not adequately seal the cap-slots. If the slots are not sealed properly, vapors can pass from the caps to the tray above without contacting liquid on the tray. This results in a marked reduction in tray-efficiency. Our tests indicate that a liquid seal of 0.5-in. will prevent coning in most cases.

Blowing. Blowing results when the amount of vapor passing through the caps is so great that it literally tears holes in the liquid on the tray. This condition gives poor vapor-liquid contact with a consequent reduction in tray-efficiency.

The blowing-limit of a bubble cap tray is influenced by four things. The size of the caps. The area of the bubble cap-slots. The skirt-clearance between the cap-teeth and the tray. And the properties of the hydrocarbon-system.

Entrainment. Several undesirable effects are associated with the entrainment of liquid in a column. Off-grade overhead-product. A reduction in tray-efficiency. And possibly, decreased column-capacity.

Entrainment of liquid is of two types. A relatively fine mist is carried to the tray above by superficial vapor-velocity. And large droplets of liquid are jetted from one tray to the next.

Entrainment due to superficial vapor-velocity is usually less than one weight per cent of the vapor, and is somewhat independent of tray-spacing. Entrainment due to a jetting-action on the tray can amount to several weight per cent of the vapor. This type of entrainment occurs at high vapor rates and is greatly influenced by tray spacing, size and type of bubble caps, tray layout, fluid properties, and liquid rate.

Additional results of our work show that air-water tests alone cannot be used to predict entrainment for hydrocarbon-systems. And in most cases, entrainment is not a limiting factor in column-capacity.

Flooding. Flooding is a phenomenon well known to all operators of commercial columns. It occurs when the level of the liquid-foam mixture in the downpipe builds up and overflows to the tray above. Liquid continues to build up in the column, resulting in an inoperable condition. In the extreme, liquid flows out the top of the column.

The flood-point of a column is reached when the liquid and vapor-rates cause the downpipe to completely fill with a liquid-foam mixture. The flood-point is computed from a knowledge of such things as pressure drop, hydraulic gradient, liquid rate, head-loss in the downpipe, and aeration factor. The aeration factor is used to determine the operating level of the mixture in the downpipe from a computed clear liquid level. It takes into account the physical properties of the fluid mixture and its velocity. The factor ranges from 0.3 to 0.9.

Results of Test-Work

To illustrate the results of our work on bubble cap trays, we have used a typical cyclohexane fractionator. We have made computations of column-size and number of trays that would have been predicted over the past six years according to the best information available at the time. Fig. 5 gives a comparison of these computations.

Some six years ago, the column would have had 125 trays and would have been 144 in. in diameter. Today, we would recommend a 114-in. column with 96 trays for the same service and operating-conditions. As shown in Fig. 6, this reduction in column-size and number of trays results in a savings of some $60,000 in terms of today's dollars — about one third column cost.

The saving in capital cost of new columns is one result of our research on bubble cap trays. An equally important result is the improvement that can be made in the performance of many existing columns.

Sample Problems

As part of the symposium, we were asked to size four bubble cap columns for conditions specified by CNGA. The conditions are given in Table 1, and the solutions in Table 2. * * *

TABLE 1. Sample problems.

Case No.	1	2	3	4
Service	Depropanizer		Absorber	
Liquid rate, gpm	800	50	550	55
Liquid density, lb/cf	35	35	45	45
Vapor rate, cfs	23	29	18.5	26
Vapor density, lb/cf	1.5	1.5	1.5	1.5
Pressure, psig	275	275	500	500

TABLE 2. Column selections.

Case No.	1	2	3	4
Diameter, inches	72	60	66	54
Tray spacing, inches	24	24	24	24
Entrainment, #/100#	1	2.5	<1	4.5
Upper opr limit*, % of design	125 (flooding)	110 (blowing)	115 (flooding)	115 (blowing)
Lower opr limit*, % of design	50 (tray stability)	20 (pulsation)	70 (tray stability)	25 (pulsation)

* Liquid and vapor.

Turbogrid Tray in Fractionation†

Structural details of open slot area, slot width, tray spacing may be varied to meet requirements of given process

Shell Development Company, Engineering Staff

TURBOGRID trays[1] are the result of an extensive research program on distillation equipment within the Shell Companies. They are simple in construction and have high capacity, low pressure drop, and low liquid holdup, while providing about the same separation, measured as theoretical plates per foot of column, as conventional tray types. Their simplicity results in low cost and ease of maintenance.

The trays consist of a flat grid of parallel slots, the grid extending over the entire cross-section of a column. The slots can be either stamped perforations in a flat metal plate or may consist of the spaces between parallel bars. Fig. 1 illustrates a typical Turbogrid tray of the parallel-bar type. The structural support framework for the bars, the bottom side of the partly completed tray, and the top side of the finished tray are shown. Fig. 2 shows the stamped-plate type Turbogrid tray; the tray consists of standard tray sections with sketch plates at the tray edge. In the picture, one of the standard sections is removed; the area covered by a standard section serves as a manway in the tray. The trays are generally installed without downcomers for liquid flow. Downcomers may be used if desired, but are usually not recommended since they reduce the effective tray area, and hence the tray capacity.

In normal operation of Turbogrid trays, the parallel slots in the trays serve as the passages for both liquid and vapor through the tray. The flow of both liquid and vapor occurs as a cycling or intermittent jet action, uniformly distributed with respect to both phase flows over the entire grid pattern. Interference of the countercurrent flow of liquid and vapor through the tray results in a buildup of liquid on the tray, the liquid holdup being approximately equal to the tray pressure drop. When grid trays are installed with downcomers they perform similarly to conventional perforated trays with downcomers.

The significant design variables of a Turbogrid-tray column are the stream properties and rates, the structural details of the tray layout, and the specific requirements of the particular separation process. The structural details that can be varied to meet the flow or process requirements are mainly the open slot area in the tray, the slot width, and tray spacing. The open area is selected to provide the optimum economic balance between tray capacity and efficiency; a large open area gives highest capacity but at some sacrifice in tray efficiency and operating range. Other factors, such as pressure drop limitations will also affect the selection of the tray free area. In some cases, holdup requirements govern the structural design of the trays. Where tolerance to corrosion or fouling is desired, slot width, and to a lesser extent bar shape, in bar-type trays, become factors to be considered. The tray spacing selected represents a compromise between the factors of tray accessibility, and the relative importance of column height and diameter. Tray spacings of 12 to 18 in. normally are used in Turbogrid installations, with 18-in. tray spacing being preferred in large columns to improve tray accessibility.

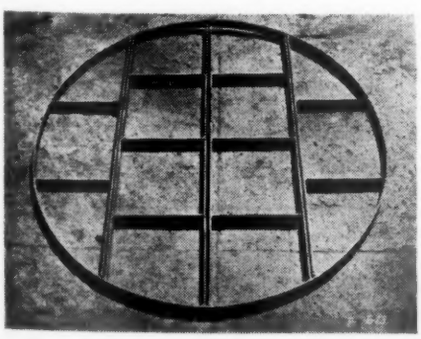
So much for construction and design. Now, how do Turbogrid trays perform? The following data on five Turbogrid-tray columns in various hydrocarbon distillation services illustrate the plant-scale performance of Turbogrids. Four of these columns are normal installations of Turbogrid trays, and one is an installation with downcomers. All of the columns have equalled or bettered design performance, and they have exceeded bubble cap tray capacity and efficiency for cases where comparative data are available.

Column 1 is 5 ft in diameter with 40 grid trays of the stamped-plate type installed at 12-in. tray spacing. The column has 19 rectifying and 21 stripping trays. The installation was designed to operate in a number of different services, and this flexibility in peformance has been substantiated in test runs. The Turbogrid trays replaced bubble cap trays which were limited in capacity and separation; however, other plant changes concurrent with the Turbogrid tray replacement preclude an exact comparison with the original bubble cap column in this case. Table 1 summarizes the rate and performance data at 15 psig for operation of Column 1 with grid trays installed for two different feedstocks. Feedstock 1 was a full boiling range straight-run gasoline and Feedstock 2 was prefractionated straight-run gasoline bottoms.

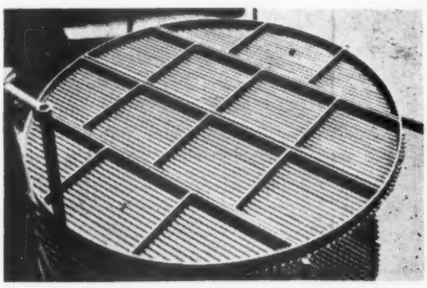
Representative feed, tops, and bottoms ASTM distillation curves are shown in Fig. 3 for Runs 3 and 7, Feedstocks 1 and 2, respectively. Fig. 4

†Presented at distillation tray symposium, California Natural Gasoline Association, Los Angeles, California, January 7, 1954.

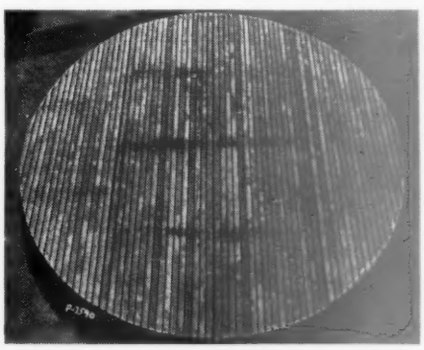
[1]U. S. and foreign patents applied for.



Structural framework for grid tray (framework cut into four sections in final assembly.)



Bottom side of partly completed tray (welding and trimming of bars and sectioning of tray incomplete).



Top side of completed tray.

FIG. 1. Typical layouts of grid trays for a depropanizer.

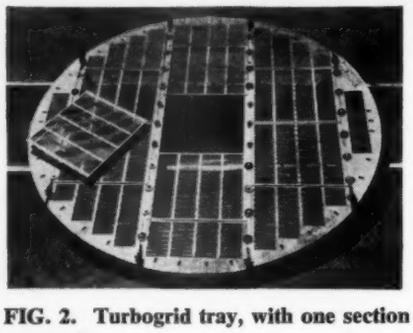


FIG. 2. Turbogrid tray, with one section removed.

TABLE 1. Performance of Turbogrid trays in gasoline fractionation, Column 1 stamped plate type trays, 12-in. tray spacing, 5 ft diameter 19 rectifying trays, 21 stripping trays.

	Feedstock 1 (full boiling range straight-run gasoline)				Feedstock 2 (prefractionated straight-run gasoline bottoms)			
Run number	1	2	3	4	5	6	7	8
Flow bbl/day feed	5300	6400	5720	4384	6000	5750	5700	5410
Tops	4100	5100	2840	3400	4350	2100	2250	2630
Bottoms	1200	1300	2880	984	1650	3650	3450	2780
Internal reflux/feed	0.522	0.332	0.627	0.358	0.472	0.686	0.491	0.343
IBP bottoms — EP tops	28	—5	26	10	—22	10	16	12
Deg API feed	59.2	61.5	58.0	59.4	50.8	51.5	51.3	51.2
Tops	62.7	66.1	67.0	63.6	53.5	58.4	58.1	57.2
Bottoms	46.8	46.8	48.0	45.3	44.8	48.2	48.2	47.9
Per cent design rates	137	132	101	96	145	128	110	91

illustrates the separation achieved with both feedstocks, measured as initial boiling point of bottoms minus end point of the tops, as a function of the percentage of design rates and the internal reflux-to-feed ratio. The data show that design separation is significantly exceeded at design feed and reflux flows and that performance is still staisfactory at 120 per cent of design feed rates. It appears, furthermore, that design separation can be expected for rates as low as 60 per cent of design, indicating a two-fold operating range in this service while meeting product specifications. The column has also performed satisfactorily as a pressure distillate stabilizer and as a debutanizer.

Calculated bubble tray capacities for well designed bubble cap trays for the test rates show that at 18-in. tray spacing, the bubble cap trays in the original installation would be overloaded (except in runs 4 and 8), with calculated downcomer backup of clear liquid equalling or exceeding the tray spacing in runs 1, 2, 5 and 6.

Column 2 is in deethanizer service. This column is 4 ft in diameter in the rectifying section and 5 ft in diameter in the stripping section. The grid-tray installation consists of 19 rectifying and 11 stripping trays at 12-in. tray spacing; the bubble cap installation it replaced had 13 rectifying trays at 16-in. tray spacing and 9 stripping trays at 24-in. tray spacing. The grid trays are of the bar-type construction.

The column is used to fractionate a feed consisting primarily of C_2's and C_3's. The principal function of the column is not strictly deethanization but rather production of a top product containing small amounts of C_3's. The original bubble cap column performed satisfactorily at a feed rate of 4950 bbl per day and 500 psia to give 96.8 per cent propylene recovery in the bottoms and 48.8 per cent of C_2's going to tops. At higher feed rates, however, the column would not operate satisfactorily unless the reflux rate were reduced, thus adversely affecting the separation. Also, the bubble cap column would not perform satisfactorily with a feed containing a high percentage of C_2's. The Turbogrid installation operates with desired reflux and separation for the higher average feed rate now required, 6000-6500 bbl per day, and can also handle the maximum feed rate of 7400 bbl per day if necessary.

TABLE 2. Performance of Turbogrid trays in deethanization.

Turbogrid trays — 19 rectifying, 11 stripping, 12 in. tray spacing
Bubble cap trays — 13 rectifying, 9 stripping, 16 in. and 24 in. tray spacing
Feed rate 4800 bbl per day; reflux rate 2000 bbl per day

	% Recovery in tops		% Recovery in bottoms	
Component	Bubble cap	Turbogrid	Bubble cap	Turbogrid
C_2=	59	66		
C_2	49	45		
C_3=			95	95
C_3			97	98

Comparative bubble cap and Turbogrid tray performance is summarized in Table 2 for flow rates that could still be handled satisfactorily by the bubble cap column. It is seen that the grid-tray installation achieves a separation equal to the bubble cap trays at flow rates close to maximum for the latter. The separation shown is maintained at feed rates of 7400 bbl per day for the grid-tray installation, while in the case of the bubble cap tray it deteriorates rapidly for feed rates in excess of 5000 bbl per day.

Turbogrid trays in Column 3 are in

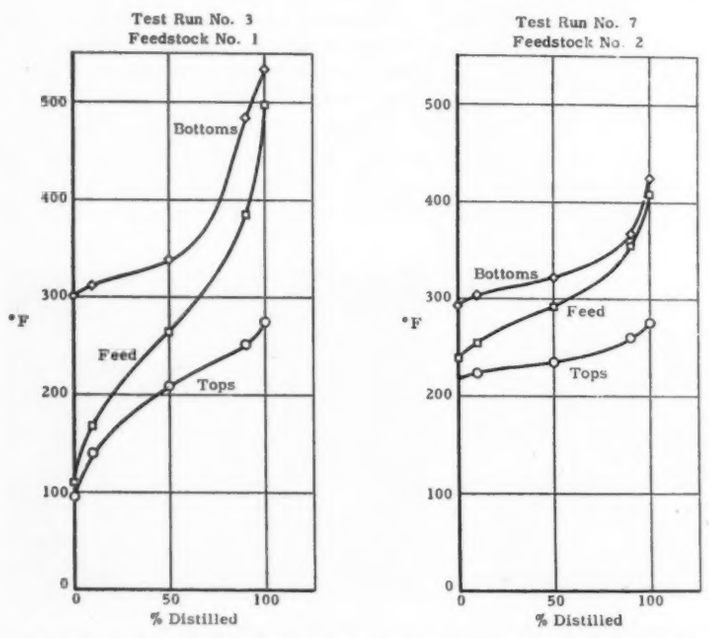


FIG. 3. ASTM distillation data on performance of Turbogrid trays in gasoline fractionation.

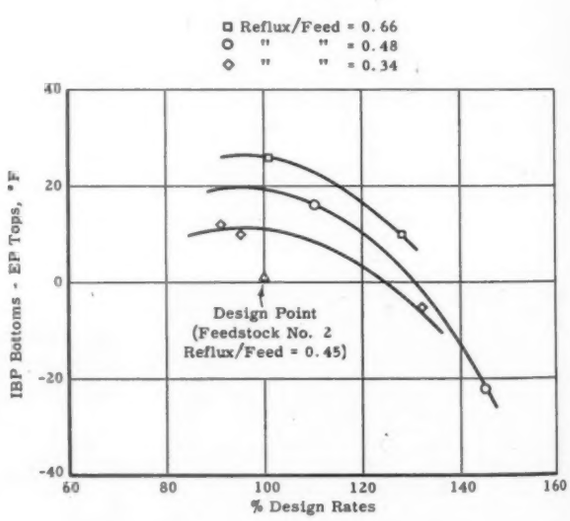


FIG. 4. Performance of Turbogrid trays in hydrocarbon fractionation. Col. 1 (40 plates, 5-ft diam., 12-in. tray spacing, on feed stocks Nos. 1 & 2, Table 1).

the stripping section of a 5 ft diameter depropanizer column operating at 230 psig. In this intallation, 19 Turbogrid trays (15 at 12-in. tray spacing, 4 at 18-in. tray spacing) replaced 14 bubble-cap trays at 18-in. tray spacing. The circumstance requiring the change from bubble cap to Turbogrid trays was not in this case one of capacity or separation limitation of the bubble cap installation. A routine column inspection had indicated the bubble cap trays to be badly corroded, with tray failure and consequent poor performance incipient. Bubble cap tray replacement could not be obtained in the requisite time, while grid trays were designed, fabricated, and installed within six working days.

The performance of the column was improved by the installation of grid trays in the stripping section. Comparative recoveries before and after the change, for normal feed and reflux rates, are:

	Bubble cap trays	Turbogrid trays in stripping section
Propane recovery in tops....	98.9%	99.3%
Butane recovery in bottoms..	97.7%	98.2%

The Turbogrid trays gave satisfactory separation for feed rates from 1900 to 4900 bbl per day, and did not flood at the latter rates (calculated as 80 per cent capacity). Test run data gave a calculated grid-tray efficiency of at least 60 per cent at 2540 bbl per day feed and 2890 bbl per day reflux, based on the key components propane and isobutane; the low propane content in the bottoms precluded a more exact efficiency determination.

The fourth column illustrating Turbogrid tray performance is a 6-ft diameter debutanizer. The column has 20 rectifying and 14 stripping Turbogrid trays at 18-in. tray spacing which replaced, tray-for-tray, the original bubble cap trays. This column has not been operated at high capacity because of condenser and feed supply limitations; its tray efficiency at low feed rates is summarized below:

Flow rates, bbl/day		Rectifying section		Stripping section	
Feed	Reflux	% Capacity	Tray efficiency, %	% Capacity	Tray efficiency, %
7,300	2200	28	26	30	44
10,380	2660	39	40	64	62

Ordinarily, use of Turbogrid trays at 25-40 per cent of capacity is not recommended; the separation achieved in this column at low rates, however, has been satisfactory and the tray efficiencies obtained in the test runs were substantially in agreement with those used in the design procedure for grid trays.

The last example, Column 5, features the only plant installation using trays with downcomers. In this column, a deethanizer, 16 grid trays replaced an equal number of bubble cap trays at 24 and 30-in. spacing in the stripping section. Purpose of the installation was to increase column capacity. Installation with downcomers was chosen to avoid mechanical complications attending the removal of downcomers welded to the column shell. Performance of the installation has been satisfactory for rates 25 per cent in excess of those limiting bubble cap tray operation, and no loss in separation has been experienced. Separation achieved in the original bubble cap tray installation under near capacity conditions that has been duplicated or bettered in grid tray operation is:

	Recovery in tops	Recovery in bottoms
C_3's and lighter.....	98.8	1.2
C_3's and heavier.....	10.3	89.7

This separation has also been achieved in the Turbogrid installation for feed rates as low as 75 per cent of the attainable bubble cap rates. The maximum column capacity with grid trays, which has not yet been reached, is estimated to be 35 per cent greater than the limiting bubble cap column capacity.

It is evident from these performance studies that in the operations considered Turbogrid tray capacity is substantially greater than that of the bubble trays replaced, and that in the cases where comparisons were possible, the separation efficiency of the Turbogrid column is superior. Their simplicity, which generally results in lower-cost installations and easier maintenance, are additional attributes of Turbogrid trays. * * *

P 734.51

Perforated Plate Distillation Columns

More than 70 sieve-tray columns are operating, largest 11-ft diameter; plates cost 25-50 per cent as much as bubble plates

D. C. LEE, JR.*

PERFORATED plates have been used for many years in distillation and absorption columns, but their popularity has never equaled that of bubble plate columns. It is felt that the greater application of bubble trays has been due largely to the lack of available design data on perforated plates and to the ease of "rough design" of bubble cap trays. Sieve plates have been reported to suffer from a narrow operating range while bubble cap trays operate well over a fairly wide range of rates. Certain features of perforated plates such as low cost, high efficiency, and capacity, and resistance to fouling, however, make their use attractive if reliable design information is available.

Until the summer of 1949 the experience of the Celanese Corporation of America had been limited to conventional bubble cap trays. At that time an experimental study of perforated plates was initiated for the purpose of making a visual comparison of the behavior of perforated plates with bubble cap trays, of determining the operating range limitations of perforated plates, and the development of sieve plate design methods. Experimental results, which have previously been reported,[3] indicate that properly designed sieve plates would have a wide range of stable, efficient operation, and that the use of perforated plate distillation and absorption columns would be desirable. Data by authors[1, 2, 4] have also stressed that sieve plates can be designed to give a wide range of efficiency operation.

*Celanese Corporation of America.

Experimental

Experimental work was performed on a 6½ ft diameter column with a single sieve tray operating on the air-water system. Manometers were used for measuring pressure drop across the tray and liquid depths on the tray performance could be observed from above the tray and also from below the tray through windows. Data were taken on such operating variables as the weep point, the maximum vapor rate possible, and pressure drop.

Runs were first made on ⅛ in. diameter holes. These were later drilled out to 3/16 in. holes and then to ¼ in. holes. For each hole size varying numbers of holes were used to check the effect of per cent hole area, and various outlet weir settings were used to investigate the effects of different liquid depths on the trays. Fig. 1 is a plot of

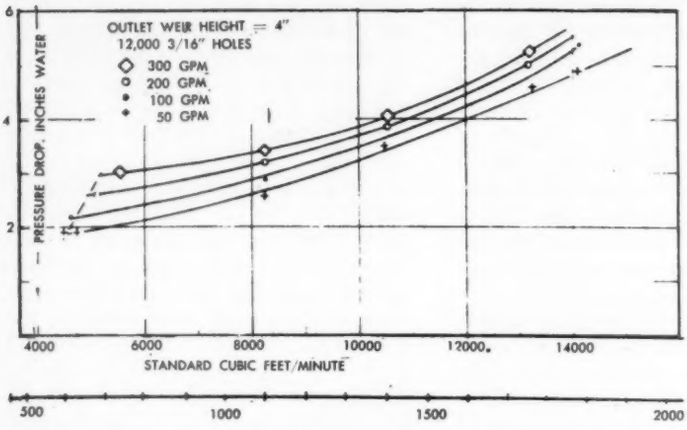


FIG. 1. Curves showing wide range of stable tray operation with sieve-plates. Pounds per hour per square foot of column area air rate.

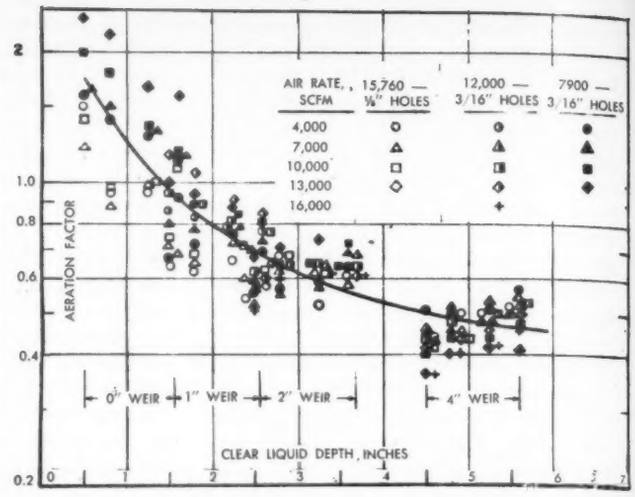


FIG. 2. Curves showing trend toward decreasing aeration factors with increasing liquid depths on trays.

typical data obtained during the runs, with the curves showing actual limits of good operation.

Orifice coefficients determined from pressure drop measurements on the 6½ ft diameter tray were not always consistent, particularly with the ⅛ in. diameter holes, where errors were introduced by a nonuniformity of hole size and shape because of hand drilling and worn drills. Therefore, a separate pressure drop study was made in a 6 in. diameter column. In this work the holes were carefully drilled to exactly ⅛, 3/16, and ¼ in. hole sizes; and various tray spacings, plate thickness and drilling patterns were studied. The calculated orifice coefficients for the dry tray pressure drop were essentially constant at about 0.85 with the plate thickness drilling pattern and hole diameter having no appreciable effect on the coefficient over the range studied.

The study of the pressure drop through dry trays in the 6 in. diameter column was expanded to investigate the effect of liquid on the orifice coefficient. It was demonstrated that the dry orifice coefficients were not appreciably affected by the presence of the liquid above the holes and that for design purposes the total pressure drop through a sieve tray could be determined by adding the individual pressure drops through the dry tray and through the calculated depth of liquid.

In analyzing wet tray pressure drop data obtained on the 6.5 ft diameter tray, it was noted that the observed pressure drop through the liquid on the tray, which was determined by subtracting the dry tray drop from the observed total pressure drop, was in some cases greater than the calculated clear liquid depth on the tray and in other cases was less than the calculated value. Aeration factors, defined as the ratio of the observed pressure drop through the liquid to the calculated clear liquid head, were calculated from this data. A correlation of this aeration factor as a function of liquid depth on the tray is shown in Fig. 2, which shows the general trend of decreasing aeration factors with increasing liquid depths. This correlation gives an estimate of the pressure drop through the liquid on sieve trays as a function of weir height and liquid rate. In the range of outlet weir heights normally used (1 in. to 2 in.) the aeration factor is less than 1.0. As these data are for the system air-water and the effect of different liquid and vapor densities on the aeration factor is not known, an aeration factor of 1.0 is normally assumed for design purposes so that the actual pressure drop through the liquid should be on the safe, or on the low side.

The data in Fig. 1 provides an indication of the wide range of stable tray operation that was obtained in the sieve plate study. The vapor rate at the upper limit of good operation in this series of runs was shown to be about 14,000 std cu ft per minute. The lower limit on the vapor rate, the point at which liquid began to weep through the holes, was found to be about 5000 std cu ft per minute. This corresponds to a stable operating range of 100 per cent vapor rate down to 36 per cent. Data on plant columns show operating ranges equally wide or wider.

A simple correlation of the minimum allowable vapor rate on the experimental sieve plate for the air-water system is shown in Fig. 3 in which the calculated liquid depth on the tray was plotted against the pressure drop necessary to support this amount of liquid without weeping. This correlation does not include such factors as surface tension, kinetic energy of the vapor, and tray diameter, which quite possibly have some effect on how far the vapor rate can be reduced. Operating data from several perforated plate columns indicate that the correlation is a fair method of estimating the minimum vapor rate for design purposes. Additional experimental data are needed for a more generalized correlation method which will permit more accurate calculations of the minimum rates.

In the selection of the hole size to be used, it was concluded that 3/16 in. holes were generally the most desirable for commercial use. The smaller holes appeared to give better vapor-liquid contacting, with the 3/16 in. holes almost as good as the ⅛ in. holes. The use of ⅛ in. holes with heavy-gage plate is normally not practical when punched holes are used because of the mechanical limitations of the hole punching process. The ¼ in. holes, although being the cheapest to fabricate and the most resistant to fouling, appeared to give poorer vapor-liquid contacting due to wider spacing of the holes and to a tendency of the vapor to jet through the liquid.

Visual observations of the air-water contacting obtained with the perforated plate indicated that the tray efficiency should be higher than for a bubble cap tray. Soon after completion of the experimental work, a 60-tray by 6.0 ft column was designed and installed at the Celanese Chemcel plant. Performance checks confirmed the expected high capacity and wide operating range at high efficiency. Comparison of overall tray efficiency with that of a bubble cap column in the same service showed the sieve plate column to have a flatter efficiency curve and one which exceeded that of the bubble-cap column by 5 per cent to 15 per cent. The superior plate effi-

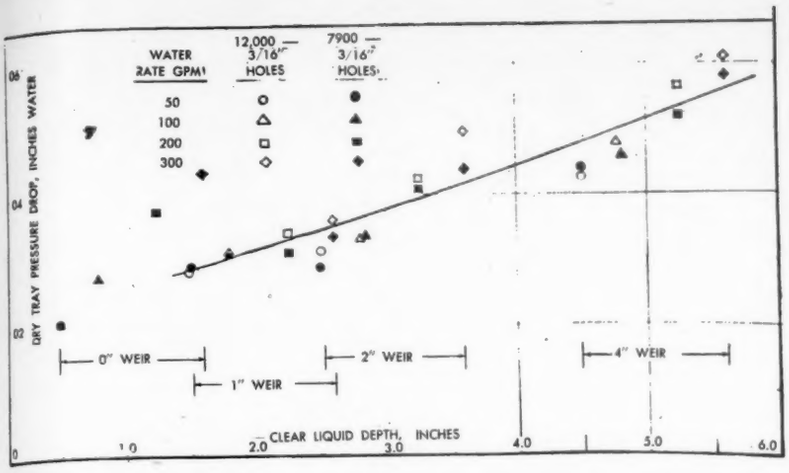


FIG. 3. Correlation of minimum vapor rate on sieve-plate for air-water experimental system.

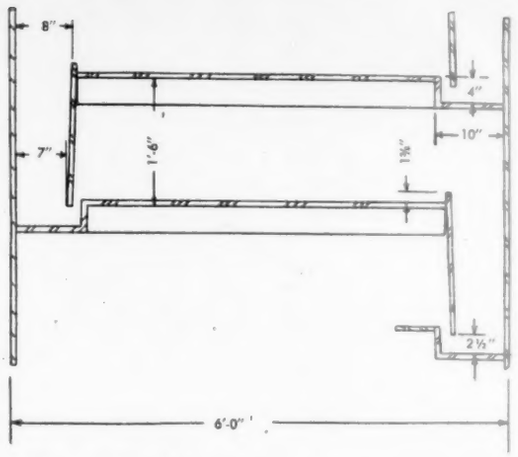


FIG. 4. Recessed inlet seal pans as incorporated in sieve-plate design.

ciency of sieve plates has also been reported by Jones and Pyle.[1]

Design Notes

Design of a sieve plate column follows the same line as the design of a bubble plate column. The column diameter, number of trays, tray spacing, and downcomer dimensions are arrived at in the same manner as for bubble trays. Allowance can be made for the somewhat higher capacity and higher efficiency of the perforated plate column if sufficient data are available for the sizing of the column this closely. In designing the proper number of holes for the tray, the major consideration is that of calculating pressure drop through the dry tray and estimating the desired range of pressure drop for the design conditions. The pressure drop is calculated by a suitable orifice equation using an orifice coefficient of 0.85 for ⅛ to ¼ in. thick plate. This is simplified to a special equation on 3/16 in. holes, in which the vapor flow rate per hole is expressed as a function of gas gravity, temperature, pressure, and pressure drop in inches of water. To obtain the component pressure drop through the liquid, an aeration factor of 1.0 is normally assumed for outlet weirs of about 2.0 in. in height. Selection of the number of holes to be used depends on the requirements of the system. If the design vapor rate is very high, say approaching the limiting rate based on cross-sectional tower area, the selected design pressure drop can be relatively high in order to allow the tower to be operated at much lower vapor rates if desired. Conversely, if the design vapor rate is considerably less than the ultimate capacity of the tower, then the selected design pressure drop might be taken much nearer the weep point to permit higher vapor rates to be obtained without a resulting excessive pressure drop. For normal operation, it is customary to assume a design pressure drop that will permit the tower to be operated both above and below the design rate.

For cases in which the vapor rate changes considerably from the top of the tower to the base, it is necessary to calculate the hole requirements at several points through the tower. In cases of this sort where the hole requirements vary through the tower, it is customary to drill all trays with the maximum number of holes and use blanking strips tack-welded to the trays to obtain the desired number of holes in each section of the tower. Carrying this a step further, it is possible to perforate all trays with a certain standard minimum hole spacing in cases where there is a chance that tower service might be changed to require additional holes at some later date A common hole arrangement in cases of this type is 3/16 in. holes on a 9/16 in. triangular pitch where 18 in. tray spacing is used. The use of blanking strips is advantageous in permitting the use of the optimum number of holes for each tower service to maintain high tray efficiency in all cases.

A feature of sieve tray operation which was noted in the visual study of the 6.5 ft diameter tray was the premature weeping of liquid on the inlet side of the tray due to the impact head developed by liquid as it overflowed the inlet weir. This was particularly true at high liquid rates in which cases the tray began weeping at relatively high vapor loadings, although in general the weepage was not severe and would probably have had no serious effect on tray efficiency. Two design features have been incorporated in practice to help reduce or eliminate

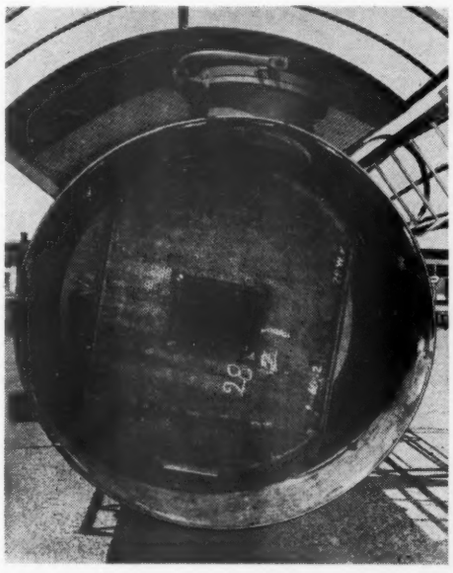


FIG. 5. Typical sieve-plate installed in Chemcel tower.

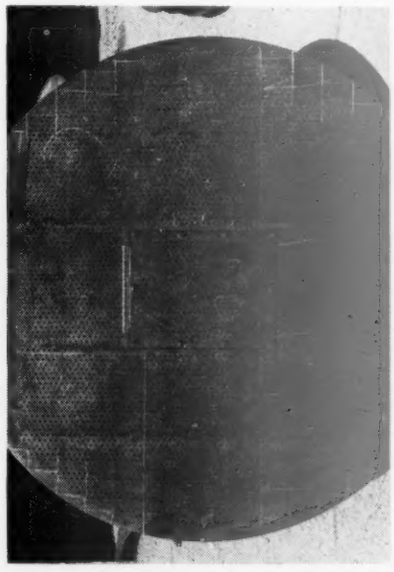


FIG. 6. Close-up of details of sieve-plate, showing bolted access manhole.

600-barrel UOP Platforming unit installed at R. J. refinery near Princeton, Ind.

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PLATFORMING CHANGES MARKETING METHODS OF R. J. OIL & REFINING CO.

By Henry P. Smith, President
R. J. Oil & Refining Company, Inc.

HIGH quality products being produced in our new UOP Platforming unit have given R. J. new stature in its marketing area and have brought about sweeping changes in marketing techniques.

Henry P. Smith

Before the Platforming unit went on stream at our refinery near Princeton, Ind., R. J. sold premium and regular gasolines at prices lower than those posted at the wholesale outlets of other oil companies.

Now, because R. J.'s gasolines have the highest octane ratings of any in our marketing area, we are commanding prices on a par with those of other companies. And a new theme song—"Fill 'er up and feel the difference"—is being chanted by motorists patronizing our stations.

Motorists are enthusiastic in their praise of the new "Platolene" premium gasoline and "500" regular—both products of the UOP Platformer.

Gasoline sales have nearly trebled since September 5, 1953, when the Platforming unit went on stream. A credit card system was established recently, and already 200 motorists in the 100-mile area R. J. serves have availed themselves of this service.

First Standard "A" Unit

The process design for the Platforming unit was handled by Universal Oil Products Company engineers. All of the mechanical design and drafting, purchasing, and construction were handled by Procon Incorporated. The unit is the first "package" installation of a Standard "A" UOP Platforming process unit.

The decision to install the Platforming unit was made after careful investigation convinced R. J.'s management that it was the ideal catalytic reforming process which would enable the company to become a leader in a marketing area where the race for higher octanes was constantly increasing.

Other factors which motivated our decision were:

—We felt that Platforming would give R. J. a more marketable product.

—We were convinced R. J. could abandon its below-market price policy because of high quality products without suffering a loss in sales.

—We believed that a Platforming unit would give the refinery sufficient flexibility so that the company could always stay on top in the octane race.

—UOP's long record of giving service to licensees.

R. J.'s Platforming unit is equipped with a desulphurizer. Raw charge consists of 400° F. straight run gasoline which goes from storage to a heater, the desulphurizer and then to a prefractionating column.

A cut of approximately 270° F. end point is removed overhead from the prefractionator. The reactor charge, taken as a sidecut from the prefractionating column, is of 400° F. end point material. The sidecut goes from the reactor charge pump through three heaters and reactors.

Recycle Gas Through Reactor

After passing through the No. 3 reactor, the material is sent to a products separator. The compressor takes suction from the top of the separator and recycles the gas through the reactor section.

The liquid bottoms product from the separator is charged to the stabilizer together with overhead material from the prefractionator. Stabilizer effluent is pumped to storage as marketable products.

Sulphur content of the charge stock is converted in the desulphurizer into H_2S, which in turn is removed from the prefractionator in a net overhead cut. The H_2S is removed overhead when this cut is charged to the stabilizer. Gas from the stabilizer is sent to a gas balance drum before being injected into the refinery fuel gas system.

R. J. has spent nearly $1,000,000 to bring to its motoring public the finest gasoline that can be produced. Because of the increasing demand for our gasoline and other products, we are contemplating an extensive expansion program. Present plans call for doubling the size of the Platforming unit from its present 600 B/SD capacity. It is hoped that this expansion program will be completed by late 1954 or early 1955.

It is our firm belief that Platforming has made R. J. an increasingly important factor in the economic life of southwestern Indiana, and that the company will continue to grow and prosper because of the superior quality of its products made possible by Platforming.

first
600 barrel
UOP Platformer
on stream

designed, engineered and licensed by

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD,
DES PLAINES, ILL., U. S. A.
Laboratories: RIVERSIDE, ILLINOIS

Universal Service
Protects Your Investment

this problem. The first is the use of recessed inlet seal pans as shown in Fig. 4. In this type design the liquid flowing out of the downcomer has less distance to fall, and therefore the tendency of the liquid to be driven through the holes on the tray at that point is reduced. Another advantage of recessed seal pans is that it provides a deeper seal for downcomer backup. In addition to the use of recessed seal pans the trays should normally not be perforated closer than 2 in. to 4 in. from the inlet weir. In cases of high liquid loadings, this undrilled space could be made even wider to help prevent impact-type weepage.

In the farbrication of new towers, trays are deliberately tilted a slight amount toward the outlet weir (about ⅛ in. to ¼ in.) to minimize hydraulic gradient effects and to insure that workmanship tolerances in fabrication do not result in occasional trays being tilted towards the inlet weir.

Use of punched holes has led to one possible inaccuracy in the design methods although operating data to date have shown no appreciable errors from this source. The perforating process tends to shear or tear the material from the tray after the punch has penetrated about half way through. This gives a clean sharp hole only part of the way through the tray and a rather ragged, enlarged hole the remainder of the way. By placing the sharp edge of the holes down, any changes in the orifice coefficient are minimized. Actual measured pressure drops in columns with this type tray have checked fairly closely the values calculated from orifice coefficients for smooth drilled holes.

Figs. 5 and 6 show photographs of typical sieve plate installation in Chemcel towers.

Most new columns for the Celanese Corporation are now sieve tray installations. More than 70 sieve tray columns have been installed in the last three years, the largest being one of 11 ft diameter. Where a few replacement trays are needed in corrosive sections of bubble cap columns, sieve plates are commonly used as the replacements. Reason for the selecton of sieve trays is to make use of their advantages when proper design methods are available. The first cost of a sieve tray column is substantially less than for a bubble cap column, even if no reduction in column size is made. Estimates of the costs of the plates alone show that sieve plates cost 25 to 50 per cent as much as bubble cap trays. With the sieve tray installation, greater capacity and efficiency are realized, and the range of operation is satisfactorily wide for normal operation. Finally, maintenance of the columns are facilitated because of the greater ease of work inside the columns.

References

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* * *

Benturi Kaskade Tray†

This new design is fractionating product of 3-to-8 F boiling range; 99.5 per cent pure propane made without stripping steam

G. C. THRIFT*

THE Kaskade tray[1, 2, 3, 4] which was first used commercially in 1943 after extensive laboratory study now has approximately 350 installations in an extremely wide range of services from 7 mm Hg. absolute to 1000 psig pressure and as low as 7-in. tray space.

†Presented at NGAA meeting April 21-23, 1954, Dallas, Texas.

*Koch Engineering Co.,, Inc.

Evolution of the "Benturi" type, announced in 1952[5] after two years of commercial use, was a result of extensive study of operating results and design variables affecting plate efficiency and throughput. The simplicity and lower pressure drop per theoretical plate have contributed greatly to its increased popularity. Dry tray pressure drop, as expressed by the familiar orifice formula: $U = c\sqrt{2gh}$, a constant "c" of as high as 0.92 may be used. This means that 92 per cent of the slot energy is available as mixing energy. Despite current practice of using high bubble tray efficiencies, operating results in many ranges have indicated higher efficiencies than would be expected of conventional bubble trays.

Efficient use of the higher available Benturi slot energy for more complete mixing of the two phases has resulted in higher efficiencies in the ranges of butane and heavier liquids. Increased efficiencies are more pronounced in viscous range such as absorption oils and heavier. Butane separating efficiencies well in excess of 100 per cent can be predicted under many conditions. Absorption tray efficiencies in the range of 75 to 100 per cent have been experienced, whereas bubble tray efficiencies in the range of 25 to 30 per cent would be expected. See Table 4.

Both the original Kaskade and the later Benturi have very similar slot velocity vs efficiency curves, the pla-

FIG. 1. Illustrating the "Flexitray" installed in the upper, moderately loaded zone, and the "Benturi" installed in the lower heavily loaded zone of a typical light ends tower.

FIG. 2. Typical 9 ft 6 in. diam absorber tray for National Petro-Chemicals Corporation, Tuscola, Illinois.

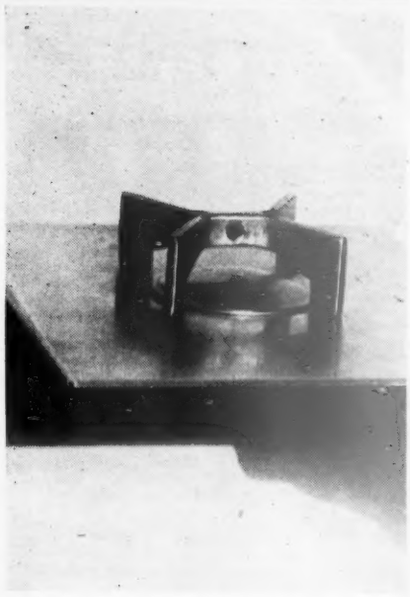

FIG. 3. The Flexitray valve in closed position.

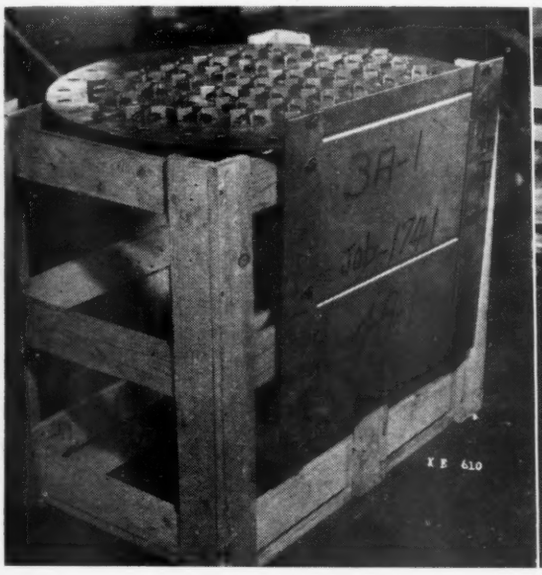

FIG. 4. Typical "Flexitray" for light ends separation. FIG. 5. Typical "Flexitray" in copper material, for the chemical industry.

TABLE 1. Comparison of Kaskade with bubble trays in high pressure absorption.

	Inlet gas both towers mol.-%	Residue gas, mol-%		Moles absorbed* per hour from gas		Per cent absorbed	
		Bubble trays	Kaskade trays	Bubble trays	Kaskade trays	Bubble trays	Kaskade trays
CO_2	0.60	0.20	0.40	—	—	—	—
C_1	89.60	93.69	94.09	120.00	124.00	13.4	12.4
C_2	5.60	4.44	4.61	19.20	19.20	34.4	30.6
C_3	2.43	1.45	0.73	12.30	20.40	50.6	75.0
iC_4	0.49	0.22	0.17	3.10	4.00	63.0	71.5
nC_4	0.70	—	—	6.90	7.80	100.0	100.0
iC_5	0.21	—	—	2.10	2.35	100.0	100.0
nC_5	0.21	—	—	2.10	2.35	100.0	100.0
C_6	0.08	—	—	0.80	0.90	100.0	100.0
C_7+	0.08	—	—	0.80	0.90	100.0	100.0
Total	100.00	100.00	100.00	167.30	181.90		
Specific gravity	0.639	0.594	0.589				
Rich gas to tower, mcfd		9090†	10,220†				
Lean oil to tower, GPM		56.5	56.5				
Pressure, psig		745	745				
Lean oil temperature, deg F.		88	88				

* From rich oil analysis.
† Calculated from residue gas meter readings.

teau of highest efficiency being at higher operating rates than obtainable with conventional bubble trays. See Figs. 6 and 7. Published ratings of Benturi trays[5] are purposely made conservative in many ranges and the Koch Engineering Company should be consulted on final ratings. Demand for a tray capacity and extremely wide operating range has led to the development of the third design of Kaskade known as the "Flexitray." This tray has ratings and efficiencies approximating those of a well-designed perforated tray yet retains an efficient operating range exceeding that of conventional bubble trays.

Due to its simplicity, low weight and adaptability to mass production, this

TABLE 2. Comparison of Kaskade and bubble tray absorbers.

	Kaskade tray	Bubble tray
Diameter, ft	6	7
No. absorption trays	16	20
Residue gas vol., st cu ft/day	27,800,000	27,600,000
Oil rate, gpd	314,500	308,500
Pressure, psig	51.5	51.5
Lean-oil temp., deg F	69	69
Rich-oil temp., deg F	90	90
Lean-oil gravity, deg API	41.0	41.0

Pod. analyses—	Inlet gas mol. vol. %	Residue gas mol. vol. %	Inlet gas mol. vol. %	Residue gas mol. vol. %	Lean oil mol. vol. % liq. vol. %
Nitrogen	.....	.84	1.13	.91	.....
Oxygen	.....	.14	.13	.13	.....
Methane	81.41	82.78	79.76	82.42	.....
Ethane	10.63	10.47	10.84	10.14	.....
Propane	4.60	4.18	4.76	4.47	.....
Isobutane	.70	.37	.48	.32	.....
n-Butane	1.37	1.19	1.64	1.30	.....
Isopentane	.35	.15	.29	.11	.11 .09
n-Pentane	.45	.09	.49	.11	.44 .37
Hexanes	.12	.05	.28	.09	.60 .57
Heptanes+	.37	.04	.20	.....	98.85 98.97
Total	100.00	100.00	100.00	100.00	100.00

Note the leaner gas from the Kaskade absorber with fewer trays.

TABLE 3. Performance of low pressure absorber.

Component	Mol-% Rich gas	Mol-% Lean gas	Absorption* Mol/100 Mol Rich gas	Absorption* Per cent on feed
C_1	79.87	88.25	0	0
C_2	6.45	7.13	0	0
C_3	6.20	4.11	2.48	40.0
iC_4	1.35	0.38	1.01	74.8
nC_4	2.32	0.13	2.20	94.8
iC_5	0.77	.....	0.77	100.0
nC_5	0.17	.....	0.17	100.0
C_6+	2.87	.....	2.87	100.0
	100.00	100.00	9.50	

Eleven Tray Absorber

	Theoretical Trays (Calc.)	% Efficiency	% Absorbed
C_3	2	18.2	40
iC_4	5	45.5	75
nC_4	8	72.6	95

* Assuming no C_1 or C_2 is absorbed

TABLE 4. Natural gas absorber, operating data.

Conditions — 172 psig, 73 F, Gas constant at low rate.
Liquid volume varies,
High propane recovery
40.6 deg API lean absorption oil.
10.164 MMCF/D rich gas in.
5′-6″ I.D. tower, 24 Kaskades on 26 in. spacing.

	Test Basis Design	Test #1	Test #2	Test #3
% C_3 recovery	93	95.8	96.29	96.95
Lean oil rate Gal/MCF	67	50	60	67
No. Theoret trays	8	20	16	12
Eff. % (Obtained)	..	83.5	66.6	50.0

TABLE 5. Refinery depropanizer operation before and after installing Benturi-type Kaskade trays.

Analysis Vol.-%	Depropanizer charge* Before	Depropanizer charge* After	Depropanizer overhead gas** Before	Depropanizer overhead gas** After	Stabilized naphtha distillate* Before	Stabilized naphtha distillate* After
$N_2 + CO_2$	..	..	..	1.7	..	..
O_2	..	..	..	.03	..	..
H_2	..	..	0.5	..	..	..
CH_4	..	..	0.2	0.4	..	..
C_2H_4	..	..	0.2	..	..	..
C_2H_6	..	..	3.8	7.3	..	..
C_3H_6	..	..	0.3	..	..	..
C_3H_8	..	..	29.3	63.8	..	..
Total C_3 cut	2.1	1.9	..	..	..	..
iC_4	..	0.7	15.3	10.4	..	..
nC_4	..	4.4	19.3	2.5	2.4	..
C_4 paraffins	4.7	..	..	..	..	5.6
C_4 olefins	0.1	..	0.1	..	..	0.1
iC_5	2.9	4.7	0.1	0.1	5.9	4.0
nC_5	6.1	5.3	..	0.6	5.4	5.3
C_6+	84.1	82.8	..	..	86.3	85.0
H_2S	..	0.2	30.9	12.9	..	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
H_2S, gm/100 ml	0.328	0.175			0.0014	<0.0005

* Low temperature fractional distillation.
** Mass spectrometer

Tests:						
Gravity, deg API	63.1	62.3	..	..	62.2	61.6
Vapor Pressure	..	9.6	1.575 (sp. gr.)	1.548 (sp. gr.)	..	6.4
Distillation (ASTM) deg F.:						
IBP	102	94	..	..	110	100
5	134	136	..	..	148	138
10	152	154	..	..	160	154
20	176	178	..	..	178	176
30	194	198	..	..	194	196
40	207	214	..	..	206	212
50	220	228	..	..	219	226
60	231	242	..	..	230	240
70	243	256	..	..	240	252
80	256	272	..	..	254	270
90	273	294	..	..	279	289
95	290	310	..	..	282	304
E. P.	336	336	..	..	328	341
Rec., %	98.0	98.0	..	..	98.0	98.0
Yields, Vol. %	21.16†	27.46†	3.2††	2.5††	20.50† 96.8††	26.79† 97.5††
Rates, bbl/hr	375	488	21.412 Mcfh	21.511 Mcfh	363	476

†Based on crude
††Based on depropanizer charge
Note increased capacity after Kaskade replacement of bubble trays.

TABLE 7. Kaskade results in crude distillation service.

Produce	Gasoline*	Kero	Distillate	Residue
volume %	20.0	19.0	19.0	40.0
sp. gr.	.707	.793	.846	.962
ASTM:				
IBP, deg F	108	316	487	
10%	151	345	522	
20	167	356	529	
30	183	360	532	
40	198	363	541	
50	212	378	550	
60	226	387	561	
70	239	399	572	
80	252	412	588	
90	270	430	604	
EP	300	452	631	

* Blend of light and heavy gasoline from preflash and main fractionator.

TABLE 6. Typical Kaskade throughput data.

Diameter,ft	6′-6″	6′-0″	6′-0″	5′-6″	5′-6″	4′-6″	2′-6″	2′-6″
Tray space, inches	24	24	36	24	27	30	24	24
Tower service	Absorber	Deprop.	Syn tower	Syn. tower	Absorber	Debut.	Debut.	Debut.
Vapors								
lb/hr	117,000	148,000	82,480	74,700	121,000	83,000	36,000	27,832
Cv, lb/CF	.81	3.06	0.175	.217	3.113	2.34	2.0	1.84
Liquid								
Gpm	1070	860	319	156	405	485	100	80
Cl, lb/CF	50	29	45.1	40.4	41.4	34.0	36	36

TABLE 8. Operation summary—Kaskade fractionating towers naphtha unit.

	Naphtha				
Type of column	No. 2	No. 3	No. 4	No. 5	No. 6
Diameter (I.D.)	3′-0″	3′-0″	3′-0″	3′-0″	3′-0″
Number of trays	20	20	20	20	20
Charge b/d	3258	2114	1704	1214	701
Overhead b/d	1144	410	490	513	644
Bottoms b/d	2114	1704	1214	701	72
Gap (5%—95%) deg F	45	25	45	29	41
Gap* (IBP—EP) deg F	13	—3	20	—3	31
Cold reflux ratio (R/O)	0.35	0.98	0.92	1.75	0.39
Internal reflux ratio (R/O)	0.51	1.70	1.65	3.96	1.13
Superficial velocity (ft/sec.)	2.08	1.89	2.08	4.27	2.28
Top vapor load (% brown souders)	96	94	102.5	194	121
Bottom vapor load (% brown souders)	165	33	116	254	116
Liquid load (GPH/in. weir)	218	94	115	180	69
Pressure	30	5	6	8	5

* Minus sign indicates overlap.

tray is recommended when the tray cost is inherently an appreciable percentage of the total tower installation costs. Typical installations are moderately high liquid rates, essentially atmospheric or moderate pressure with carbon steel vessels, or above the feed zones in light ends fractionators. The "Flexitray" is also adaptable to many absorber problems.

The Flexitray, more completely described in current literature[6], has liftable caps approximately 2-in. diameter, held down by plate stamped spiders whose projections are clinched on the underside of the deck. See Figs. 3, 4, and 5. These caps are spaced on a triangular pitch of 3 to 6-in. in a similar manner to bubble trays. Caps and holddowns are provided in alloy even though the remainder of the tray may be of carbon steel materials. In alloy

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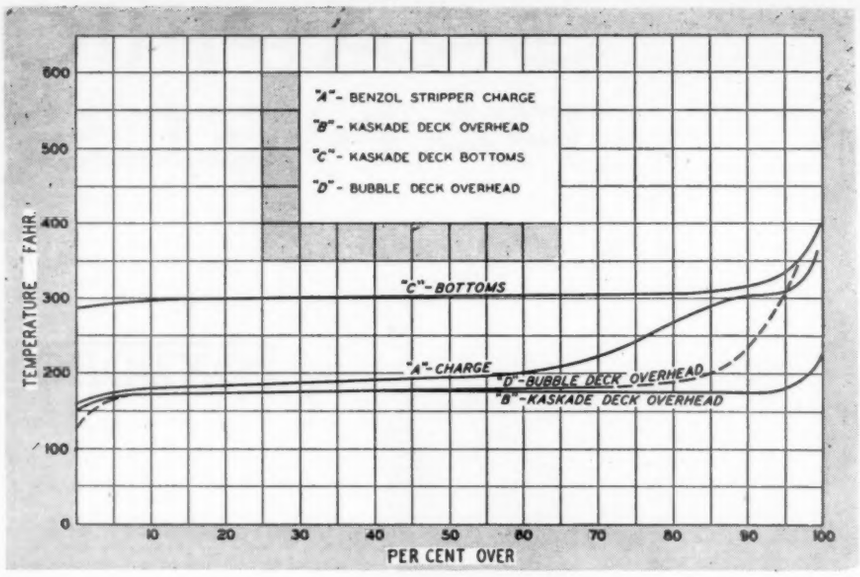

FIG. 6. Distillation curves for benzol-cumene stripper.

materials the "Flexitray" is very economical due to its inherent light weight. No gaskets are necessary, as even at the lowest loading the vapor weeps up through any small crevices regardless of Weir setting.

To insure uniform vapor distribution, at very low loads on trays inadvertantly installed out of level, alternate rows of caps are of two different weights. The absence of hydraulic gradients and the maximum slot velocity being directed horizonatally contribute appreciably to the flexibility and high throughput of Flexitrays.

Data in Table 7 were taken while charging 9500 bbl per day of Iraq crude of 0.853 sp grav to 6 ft 10 in. diameter main fractionator containing 31 Benturi type Kaskades on 24-in. spacing. Tower is equipped for 2 side cuts, only two of which were in service during this operation. This tower was operating below design rate and maximum efficiency during this test.

Here the lower pressure drop per tray (2 to 3 in. H_2O) has resulted in lower Flash zone pressures and temperatures, resulting in higher yields of good quality kerosines with a minimum of chemical treatment. This Kaskade replacement of bubble trays, on the same supports, gave a substantial

TABLE 9. Efficiency test of Kaskade tray in solvent extraction.

(System: Furfural + 5% water—Cyclohexane—water)

Solvent Rate gal./hr./sq. ft.	Solvent Rate ft./min.	Number of Theoretical stages (Batch extraction single and multistage)	Per cent efficiency
	Furfural dispersed: column upright		
450	1.1	1.2	20.0
580	1.4	1.4	23.3
750	1.8	1.4	23.3
	Hydrocarbon dispersed; column inverted (Two runs each test)		
420	1.0	2.1	35.0
600	1.4	2.3	38.3
750	1.8	2.8	46.6

Tray efficiencies hydrocarbon dispersed column inverted (Average of two runs)

Tray Number	Efficiency % of 1 Stage
1 (Top)†	54
2	26
3	31
4	35
5	44
6 (Bottom)†	53

- Flow ratio: 9.5 lb. solvent per pound of cyclohexane at 86 F.

† Includes extraction in 2-ft end section

Naphtha Distillation

Kaskades are fractionating products to 3.2 F to 8 F boiling range with relatively few trays and low reflux ratios. Ninety-nine and five-tenths per cent purity propane is being produced in several installations.

Production of high purity naphthas, solvents, and chemicals from complex mixtures has always been the real test of fractionating efficiencies for conventional bubble trays.

The consistently outstanding results of Kaskades in such services have proved their superiority.

Distillation curves of charge and products for a train of five naphtha fractionating towers equipped with Koch Kaskade trays, are shown at the right. Following No. 2 tower, the feed to each is bottoms from preceding tower. No stripping steam is used in any tower.

When these sample were drawn the various towers were operating at from 18.5 to 140 per cent of nominal design rating — a true test of Kaskade flexibility.

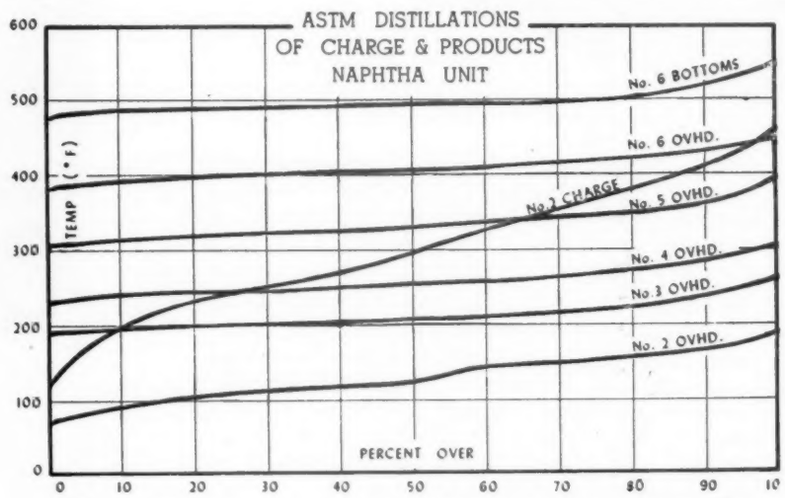

FIG. 7. Distillation curves for naphtha charge and products from a typical unit.

TABLE 10. Operating results of experimental treating with Koch Kaskade tray model in Mercaptan extraction.

Gasoline Rate— gpm	Linear velocity of gasoline in Kaskade tray Model— Ft./Min.	Necessary b/d gasoline rate on 3'-9" extraction column to give same linear velocity	Copper No. of NaOil prewashed gasoline feed	Copper No. of treated gasoline	Tannin treating solution rate ggm	Tannin treating solution Vol. % gasoline	Carry-over pounds/ 1000 bbl
3.80	1.01	2850	18.0	8.00	0.78	20.5	4.25
4.00	1.07	3050	18.0	7.40	1.00	25.0	5.60
5.25	1.40	3950	18.0	8.00	1.00	19.0	5.25
6.60	1.76	5000	18.0	7.40	1.44	21.8	5.88
7.85	2.10	5950	16.0	9.20	0.84	10.7	5.00
2.00	0.53	1500	16.0	6.80	0.60	30.0	2.67
2.00	0.52	1500	16.0	5.20	1.20	60.0	4.12
7.60	2.03	5750	16.0	8.80	1.20	15.8	6.25
9.80	2.63	7450	16.0	10.0	0.90	9.2	7.82

Relatively constant efficiency from 45% to 95% of flood conditions has made Kaskade attractive in liquid-liquid extractions.

increase in crude running capacity.

The low pressure drop per theoretical tray has made the Benturi tray attractive in vacuum flashers and many heat sensitive materials separations.

Extensive use of Kaskades in oil refining and natural gasoline plants has encouraged their use in the petroleum industry. Installations are now in the plants of American Cyanamid, Humble, Dow, Polymer Corporation, Jefferson, Phillips Chemical, Monsanto, and National Petrochemical.

National Petrochem's installation at Tuscola, Illinois, one of the largest recently placed in operation, has five of their largest towers equipped with Kaskades. Operating at pressures of 300 to 500 psi their sizes range from 8 to 11½ ft and in height from 67 to 155 ft. These towers recover ethane and other light hydrocarbons from relatively lean pipe line natural gas. The great economies, assured efficiencies and low pressure drops dictated Kaskades' use in this large J. F. Pritchard and Company designed plant. This installation in more completely described in current literature.[6]

Kaskades are also being increasingly used in the chemical industry. At this time a wide range of: Acetons, acetates, acetylene, alcohols, amines, cumene, cyanides, fatty acids, formaldehyde, glycols, ketones, mercaptans, phenols, polymers, pyradines, resins and tar base oils are being separated with Kaskades.

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5. Thornton, Petroleum Processing, May, 1952.
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* * *

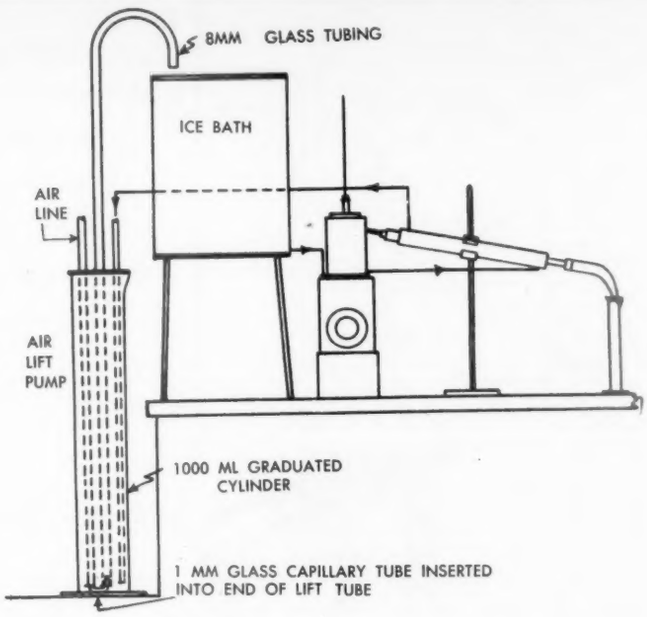
PLANT AIDS

Laboratory Type Air Lift Pump

H. D. COE**

The accompanying drawing shows the pump as used in the Delhi gasoline plant laboratory. A 1000-M1 graduate serves as a small accumulator basin and jacket for the pump. The lift tube is constructed of 8-mm diameter glass tubing approximately 100 cm in length and is bent as shown in the drawing. A small stream of air is introduced through a 1-mm glass capillary tube into the lift tube thereby providing the necessary energy used in the lifting operation. The amount of air needed depends upon the volume of liquid being pumped. For a constant air supply there will be a constant liquid head maintained in the jacket and the volume of liquid being pumped is dependent upon this head.

The pump operates as a result of two combining principles. At low air settings the density of the fluid in the lift tube is decreased, and as the density of the fluid in the outer jacket is greater, the level of the fluid in the lift tube is raised to equalize the difference in the two heads. This difference in fluid densities causes the flow of fluid from the pump jacket to a receiving vessel. At higher air rates and lower heads in the outer jacket the difference in density principle is replaced to a great extent by jet action of the air up the lift tube. Most efficient operation is obtained at lower air settings.


8MM GLASS TUBING
ICE BATH
AIR LINE
AIR LIFT PUMP
1000 ML GRADUATED CYLINDER
1 MM GLASS CAPILLARY TUBE INSERTED INTO END OF LIFT TUBE

**Sun Oil Company, Delhi, Louisiana.

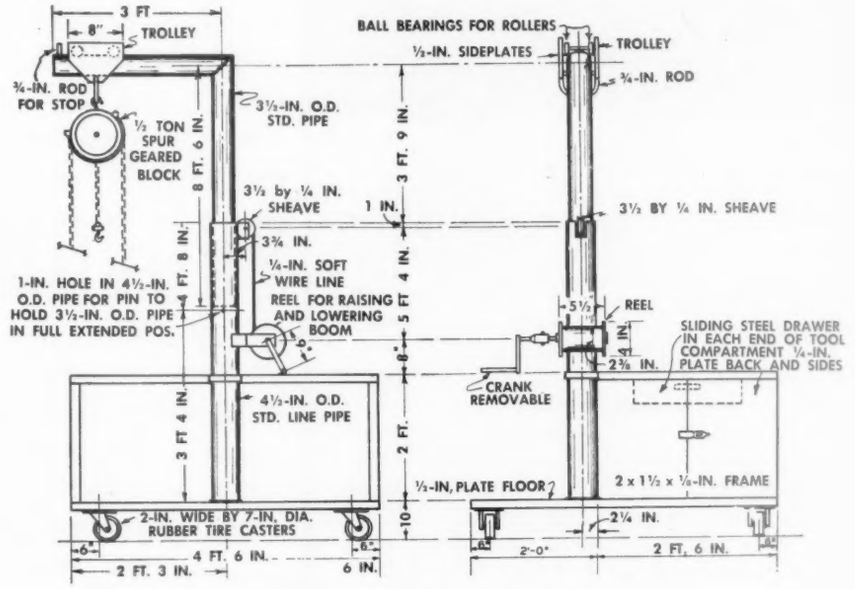
Combination Tool Wagon, Work Bench, And Portable Crane[3]

G. I. HARKRADER‡

This has proved to be a very efficient labor saving device for removing cylinder heads, cylinders, and pistons from electric generating engines such as Ingersoll Rand PVG 6 and 8 cylinder types, situated side by side so as not to permit the use of overhead traveling crane. Any good welder can build this machine in about 20 hr, and it will pay for itself on the first overhaul job.

The boom lowers to permit passage under piping and other obstructions, then raises in order to lift engine parts with sufficient clearance. They can then be swung as much as 180 deg or more and lowered to the floor for cleaning and repairing. The same procedure applies to re-assembling the engine. The machine can be rolled easily to any desired position about the engine by two men. The top deck is very handy to stand on while dismantling and re-assembling and inside is a large tool compartment with doors in each and sliding drawer also in each end. This space is adequate for all tools required for overhaul work.

‡Skelly Oil Company, Skellytown, Texas.
[3]Class A, third prize, NGAA — Panhandle-Plains Regional Meeting, Amarillo, Texas.



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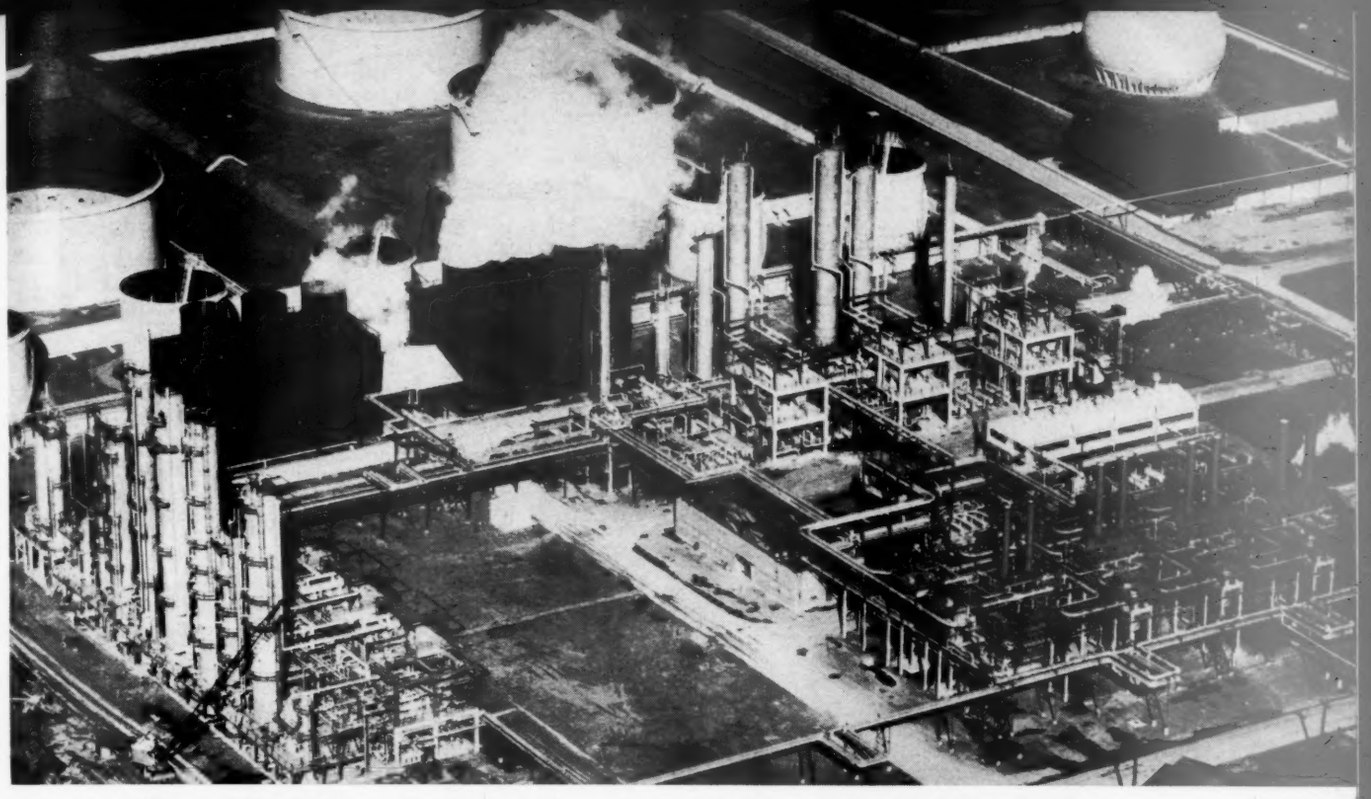


FIG. 1. Sun Oil's new $15,000,000 aromatics plant at Marcus Hook. Left: Udex unit; top-right: Prefractionating section; lower-right: Houdriformer.

P 759.6

First Eastern Aromatics Plant at Marcus Hook

Sun Oil enters petrochemical field to produce benzene, toluene, and xylenes, or gasoline blends

EUGENE B. BRIEN*

THE Northeast put in its first bid to share in the swelling petrochemical production of the nation when Sun Oil Company recently completed a $15,000,000 aromatics plant at Marcus Hook, Pennsylvania. The new plant will produce 19,000,000 gal benzene, 19,000,000 gal toluene, and 15,000,000 gal of mixed xylenes per year. Compared to the national productive capacity of these three aromatics from petroleum, the plant will produce about 6, 8, and 12 per cent of each, respectively, according to company officials.

With this plant, Sun Oil becomes a major factor in petrochemicals. It already produces substantial quantities of propylene tetramer and trimer at Toledo and Marcus Hook, as well as sulfonates and a new type of high molecular weight naphthenic acid that is practically free of oil. Its newly completed refinery at Sarnia, Ontario will produce olefins and paraffins for use in chemical manufacture in that area.

The new installation plans to take full advantage of its closeness to the eastern markets and the quick changes possible in the demand at these markets. For these reasons, J. I. Harper, Research and Development explained, the plant was designed so as to operate in three different blocked-out patterns to fit the special conditions of the local markets.

The aromatics plant can produce almost any desirable balance of benzene, toluene, and/or xylenes; or only one of the three; or none at all. In the latter case, it would produce blends for upgrading motor gasoline or aviation gasoline blending stocks. Charge rates for the individual blocked-out operations are:

Benzene-toluene operation	11,500 bpsd.
Xylenes operations	13,200 bpsd.
Gasoline operation	14,400 bpsd.

Occupying 20 acres at the already large refinery — having a crude run of 145,000 bbl per day — the aromatics plant has three basic processes fully integrated one with the other, plus a final purification step: Superfractionation (for feed stock preparation); Houdriforming (where the aromatics are made); Udex extraction and distillation (where the aromatics are recovered); and Clay treating (for purification of benzene-toluene).

Superfractionation

Preparation of Aromatics Feed Stock. Straightrun and casinghead gasoline is distilled in superfractionators into two closely cut streams to prepare feed stocks for the second process, or the main part, of the entire plant. The use of gasoline as a charge at an average

*Eastern Editor.

EXCLUSIVE

XUM

rate of 27,700 bbl per day will help diversify Sun's productions still further by offering an outlet for its inventories of gasoline. Monthly, the plant can absorb over 828,000 bbl of gasoline.

Benzene-Toluene Feed Preparation. The aromatics feed is prepared in an extremely precise series of distillation steps in four superfractionating towers or steam reboiler columns of standard design, each having about 50 or so trays and ranging up to more than 100 ft in height. (Fig 1) The virgin charge enters the first column where the C_5 and lighter hydrocarbons are separated. Removed overhead, this cut is pumped to the second column and is separated in this debutanizer into two cuts: An overhead, consisting of propane and iso-butane (14,475 bbl per month), and a bottoms, consisting of n-butane and pentane (192,925 bbl per month). Both are removed from the system at these points.

Bottoms from the first tower flow to the third column, or the benzene-toluene feed preparation fractionator, where they are distilled according to boiling points. Fractions in the stream that boil between 145 and 211 F are distilled overhead and become the charge for the Houdriformer. This stream carries the benzene and toluene naturally occurring in the virgin stocks; more importantly, it contains in greatest volume the various naphthenes (cyclohexane, methlcyclopentane, methylcyclohexane and dimethylcyclopentane) that are to be converted catalytically into the benzene and toluene end-products. The cut amounts to somewhat more than one-fourth of the original straightrun gasoline or 223,555 bbl per month.

As the superfractionating section produces benzene-toluene feed and xylene feed continuously, and as the Houdriformer can receive only one feed at one time, the benzene-toluene stream is fed directly to the Houdriformer for 19 days a month. For the remaining days, when the xylene feed is charged to the Houdriformer, the benzene-toluene feed is pumped to intermediate storage.

Xylene Feed Preparation. The first preparation step for the xylene feed stock is the same as for benzene-toluene as shown in Fig. 2. In the second step, the bottom product from the third tower flows to the fourth column, which is the xylene feed preparation tower. Careful fractionation splits this stream into three: Light gasoline fractions boiling between 211 and 240 F are taken off overhead (113,600 bbl per month) and sent to storage; naphthas boiling above 265 F are taken from the bottom (174,200 bbl per month) and out of the system; a heart-cut boiling between 240 and 265 F is taken from the tower as a sidestream at the rate of 110,000 bbl per month for the Houdriformer. This cut is rich in hydrocarbons that can be converted to xylene (ethylcyclohexane, dimethylcyclopentane, trimethylcyclopentane).

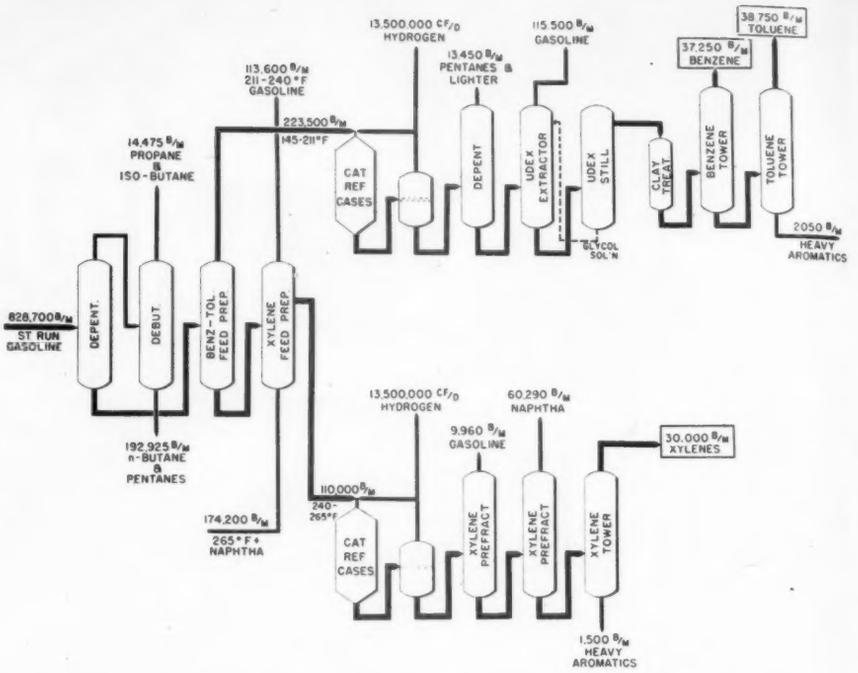


FIG. 2. Flow-sheet showing at left: Prefractionating section; upper center: Houdriformer, Udex unit, and separation section, lower center: Xylene section.

When the Houdriformer operates on benzene-toluene feed, the xylene stock is pumped to intermediate storage. Otherwise, xylene stock is pumped directly to the Houdriformer both from the superfractionating section and from storage.

Houdriforming

Conversion of Naphthenes to Aromatics. Houdriforming is the versatile catalytic process of the Houdry Process Corporation, capable of reforming naphthas to aromatics, to aviation gasoline blending stocks or to motor gasoline. Specially adapted to petrochemical production, this Sun unit reportedly is the first one to go on stream.

The benzene-toluene naphthas boiling up to 350 F end point prepared in the superfractionating section are charged to the Houdriformer at the rate of 11,500 bbl per day. This charge, combined with a hydrogen-rich recycle gas separated from the reactor effluent, is preheated through a heat-exchange with the reactor effluent stream coming out of the last reforming cases and by means of a fired coil to a reaction temperature of over 900 F. It is then passed through the first of four pairs of fixed bed catalytic reforming cases.

Each pair of reactors is followed by a pair of furnaces to raise the temperature of the materials — lowered by the endothermic reaction in the cases — back to operating levels.

The eight reactor cases hold pelleted, platinum-containing catalyst and operate at 300 psig; they receive continuously large volumes of hydrogen, recycled to prevent the deactivation of the catalyst by carbon deposits. The hydrogen should keep the reactors permanently on stream and eliminate the need to regenerate the catalyst, it is claimed.

In the reactors the cyclohexane and methylcyclopentane are converted to benzene and byproduct hydrogen; the methylcyclohexane and dimethylcyclopentane are converted to toluene and byproduct hydrogen.

Effluent from the last pair of reactors is cooled and condensed in part by water coolers. It then passes to a high pressure separator drum where the gas is separated from the liquid. The gas, largely hydrogen, is partly delivered to the recycle gas compressors for return to the reactors; the balance, withdrawn from the system at the rate of 13,500,000 cu ft per day is expected to be consumed almost exclusively by Sun in its other refinery operations, such as in the hydrogenation of distillates or in the production of other petrochemicals.

The liquid from the separator drum is charged to the stabilizer and becomes the charge stock for the Udex recovery system.

When operating on xylene feed, the Houdriformer operates as on benzene-toluene feed with this chief difference: Operating pressure is 200 lb higher, or

about 500 psig. About the same amount of byproduct hydrogen is produced as in the case of benzene-toluene conversion.

Separation of Aromatics

Benzene-Toluene Extraction. The Udex reactor, discovered, developed, and named after Universal Oil Products who licensed the Sun installation, and Dow Chemical Company, uses glycol and water to separate high-purity aromatics from other C_7 to C_{11} hydrocarbons.

The Marcus Hook Udex unit consists essentially of two towers, an extractor and a still. Bottoms from the Houdriformer cases flow to the depentanizer where pentanes and lighter hydrocarbons are withdrawn from the system (at the rate of 13,450 bbl per month) while the remaining material flows to the extractor column. This tower, using an efficient, multi-stage countercurrent design, receives diethylene glycol, the solvent, at the top and the hydrocarbon feed at the bottom. The glycol dissolves the benzene-toluene from the contaminating hydrocarbons.

From the top of the extractor, gasoline is withdrawn at the rate of 115,500 bbl per month. From the bottom, the mixture of glycol, benzene, toluene, and slight traces of undesirable materials is pumped to the second tower, or the still. By steam distillation this stripper separates the dissolved aromatics from the glycol. The recovered solvent is pumped back for re-use in the extractor.

Xylene Distillation. The xylene feed coming from the reforming cases as well as from intermediate storage is distilled in the Udex, a unit designed with three distillation towers in series. Entering the first xylene prefractionator the stream is separated into an overhead of light gasoline which is removed from the top of the column, (9960 bbl per month), and a bottom stream which is pumped to the second column.

From the top of this tower a stream of naphthas (62,290 bbl per month) is removed; from the bottom, the xylene plus some heavy aromatics is pumped to a third tower. In a final separation step the higher boiling aromatics (1500 bbl per month) are removed from the bottom, and nitration-grade xylenes from overhead at the rate of 30,000 bbl per month. As the xylenes boil at 277 F and above, careful fractionation in the last tower permits their complete separation from the heavier fractions.

Clay Treating. In the final step, the benzene-toluene stream from the Udex unit must be further purified. Passing through a catalyst at about 400 F, the undesirable olefinic contaminants in the stream are polymerized into material with a boiling point higher than that of either benzene or toluene. The two aromatics are then individually separated by distillation in two other precise fractionating columns into nitration-grade benzene and nitration-grade toluene.

Benzene is withdrawn from the top

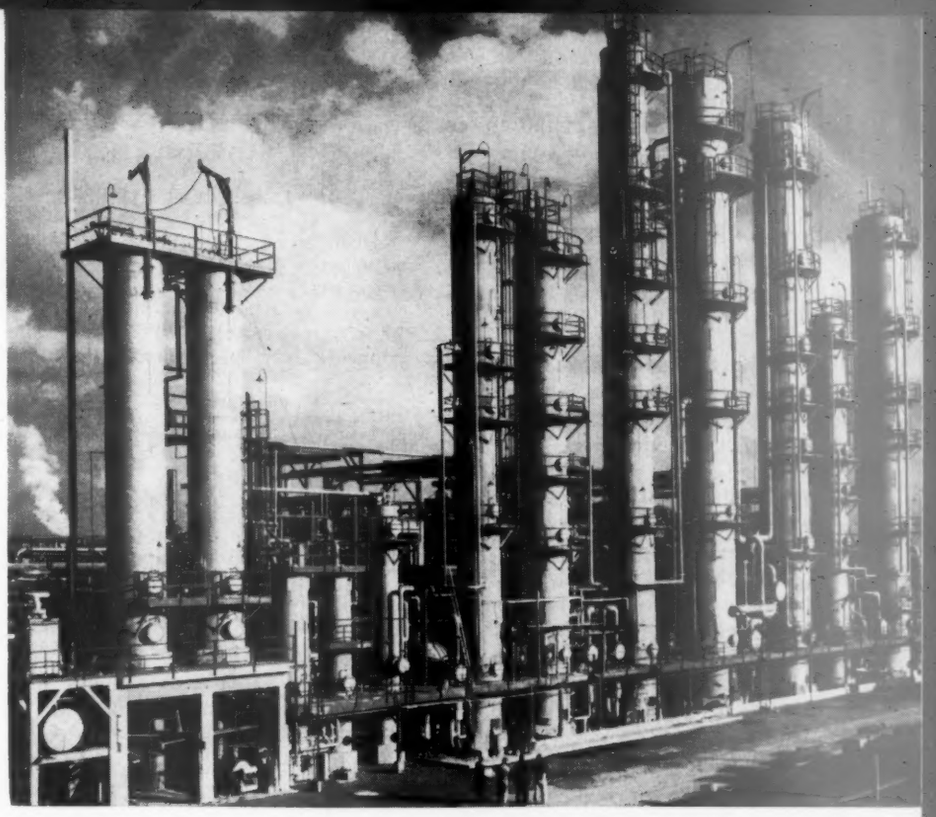


FIG. 3. Udex towers extract with glycol, distill and separate nitration-grade aromatics. Sun plant produces 6 per cent of U. S. output of benzene, 8 per cent of toluene, 12 per cent of xylenes.

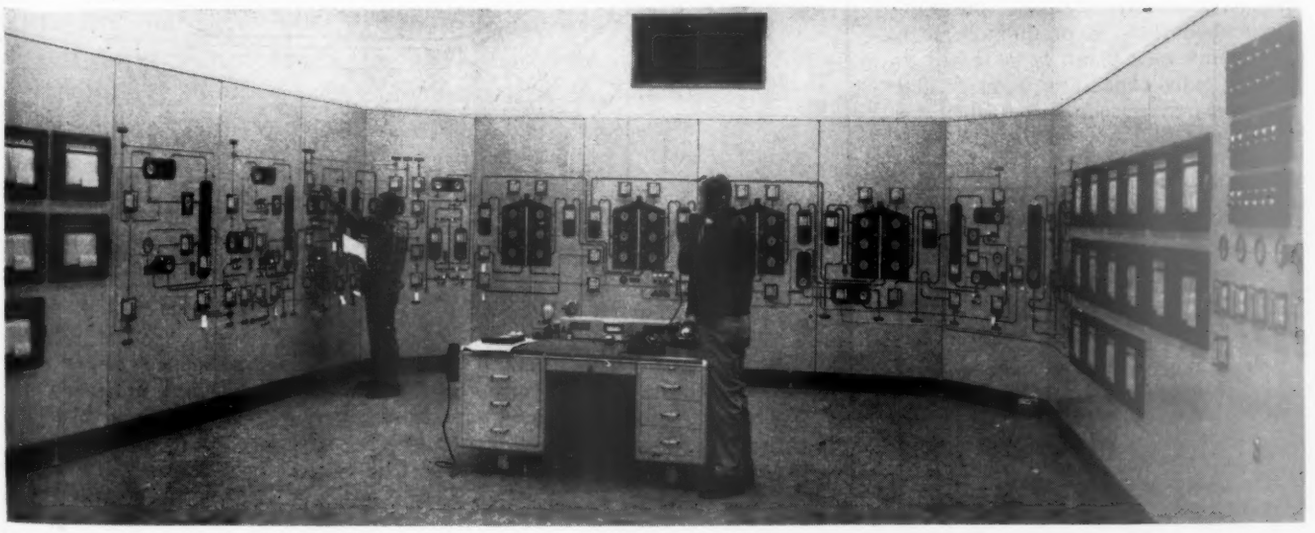


FIG. 4. Plant control panel. To read temperatures at any point in plant, operator dials and reads "Tele-Check" recorder at desk.

of the first tower at the rate of 37,250 bbl per month; bottoms of this tower are pumped to the second column in which toluene is distilled from the top at the rate of 38,750 bbl per month. Bottoms of the second tower contain a small volume (2000 bbl per month) of heavy aromatics.

The xylenes require no clay treatments.

Aromatic Petrochemicals. The aromatics, benzene, toluene, and xylene are relative newcomers to the petrochemical field, having been first produced from crude oil by Humble and Shell Oil about 1940. Already very large, their 1952 production of 1.7 billion pounds make up about 40 per cent of all petrochemical aromatics.

They have been found to be splendid building blocks for intermediates. In order of consumption, they are used as follows: Benzene, first produced from petroleum in significant volume in 1950, now goes into styrene and phenol (which consumes about 60 per cent of production) Nylon, aniline, various detergents, phenolic resins, certain insecticides and herbicides, and others.

Toluene goes chiefly into TNT and avgas (which absorb about 70 per cent of production), and into detergents and vinyltoluene. The Udex unit produces toluene of such high purity that it may be used to manufacture saccharin.

Xylene, as prepared in the Udex unit at Marcus Hook, is a combination of several xylenes. Formerly, the xylenes were used almost exclusively for solvents, but recently, they have become basic chemical building-blocks. Orthoxylene goes mostly into phthalic anhydride; paraxylene into terephthalic acid for Dacron; meta-xylene into dimethyl isophthalate (plasticizers), alkyd resins, and polymers; ethyl benzene can go potentially into styrene.

The aromatics intermediate market is still new and small. The future should hold substantially larger and more diversified markets as production, such as at Sun's new plant, is increased to meet rapidly expanding demand and new research reveals still further potential uses. * * *

Sinclair Adds Cat Reformer

A catalytic reformer employing a new platinum catalyst for producing higher octane gasoline will be built by Sinclair Refining Company at its East Chicago, Indiana, plant. It will have a capacity to increase anti-knock quality of 16,000 bbl of gasoline a day.

Contract for the reformer has been awarded to C. F. Braun & Company, and completion of the new project has been scheduled for early 1955.

How to Make An L-P Gas Burner[10]

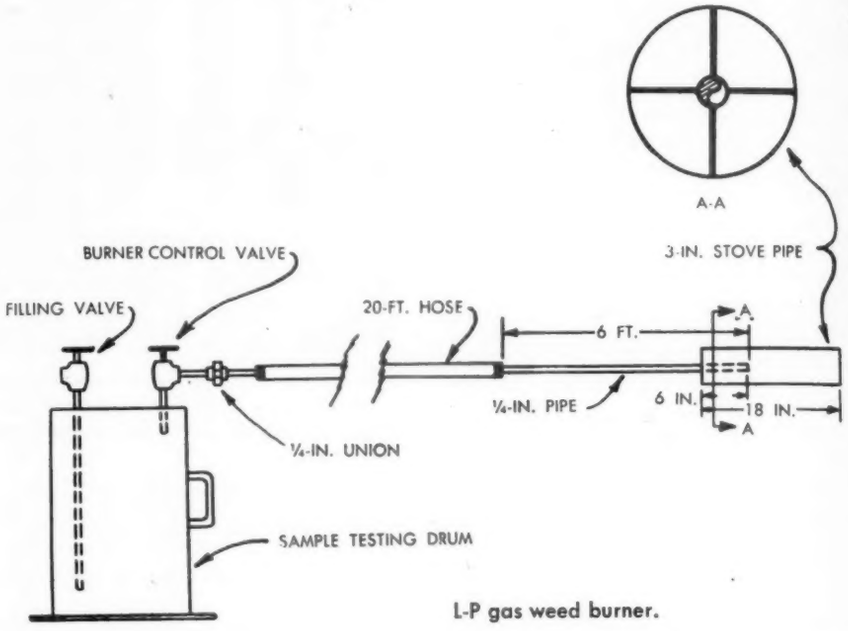
J. W. CROCKETT*

Drum is a regular testing sample drum with two ¼-in. angle valves on top. Drum is filled through ¼-in. copper tubing attached to butane or propane supply vessel. A 20-ft joint of hose connects drum to burner by means of ¼-in. G. S. Union connection at one of the angle valves.

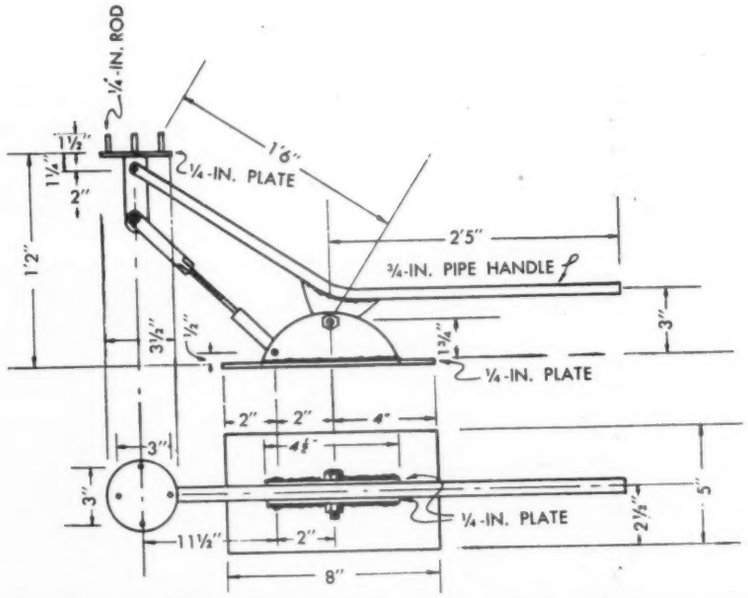
Burner mixer consists of 18-in. piece of 3-in. gas stove pipe, into which extends 6 in. of the ¼-in. pipe.

This burner is very effective for burning weeds and for burning fire lanes through grass around plant property. Two men with the burner can do the work of six men using common yard tools.

[10]Class C, third prize, NGAA — Panhandle-Plains Regional Meeting, Amarillo, Texas.
*Lone Star Gas Company, Hollis, Oklahoma.



L-P gas weed burner.



Compressor Valve Jack.[4] This devise was made for installing compressor valves in the bottom of compressors where clearance from floor or grating is too close to permit lifting by hand. It works very well on compressor valve from 8 in. diam. up.

BERT MITCHELL¶

[4]Class A, honorable mention, NGAA — Panhandle-Plains Regional Meeting.
¶Skelly Oil Company, Skellytown, Texas.

91% of gasolines surveyed contain significant amounts of copper!

While this is a staggering figure, Du Pont's latest gasoline quality survey shows it to be true . . . indicating that copper contamination resulting in gum formation poses an important problem to most refiners.

A recent Du Pont gasoline quality survey included an analysis of copper content. When the nationwide results were tallied, they revealed some startling information about this gum promoting element.

Out of 241 service station samples obtained in forty-four U.S. and five Canadian cities, *91% contained copper in significant amounts.* The copper content found in these samples ranged from .01 to .90 mg/liter. These figures are highly significant because in many cases, even concentrations of copper below .01 mg/liter have been found to be detrimental to gasoline stability.

Gum content

Because the analytical method used in this survey does not distinguish between free and deactivated copper, the analysis was carried a step further to determine the gum content of each sample. As was to be expected, the gasolines known to contain metal deactivator were low in gum content in spite of high copper concentrations. Conversely, others, without metal deactivator, were found to be high in gum content.

The results of this survey indicate clearly that, in spite of great pains taken to prevent copper contamination during refinery operation, copper is getting into the majority of gasolines sold—probably from contact with valves, pumps and other sources associated with distribution. Based on the gum findings, there are also indications that refiners who are already using a metal deactivator may not be using enough to guarantee maximum stability all along the line.

How can you be sure?..

Du Pont Metal Deactivator was developed especially to prevent copper from accelerating harmful gum formation in gasolines. And in most cases it gives effective protection for less than ¼ cent per barrel.

To help you determine the amount of Metal Deactivator required to assure that your gasoline reaches the customer in refinery fresh condition, one of our conveniently-located regional laboratories will be glad to evaluate its effectiveness in your own stocks. Address your request for this service to the nearest regional office listed below.

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With 19 major buildings for research, as many auxiliary buildings, and 1300 people on its staff, this Gulf Research and Development plant at Harmarville, Pennsylvania, is one of the most outstanding organizations.

Development of Petroleum and Petrochemical Processing: 4

Patents, Protectors for New Developments

Our patent system fulfills its original purpose of making public patent data

BENJAMIN T. BROOKS*

THE petroleum industry became acutely patent conscious in the early 1920's with the development of thermal cracking processes and the high royalties running into large sums which were paid by many companies. Standard Oil Company of Indiana is reported to have collected about $25,000,000 in royalties for use of the Burton process before this method of cracking became obsolete, which had occurred several years before the original Burton patent expired. The many infringement suits brought for infringement of various cracking patents and the high cost of such litigation also contributed to a greater awareness and understanding of patents. Patents were zealously sought for the almost sensational engineering improvements of refinery processes made during the 1920's.

When the manufacture of petrochemicals got under way most of the processes, at first, were based on known and rather simple chemical reactions and patents of basic importance were usually not obtainable and others were of doubtful validity. Therefore the details or "know-how" of such processes became all-important and because this type of information is a kind of no-man's land where patent protection often does not reach, secrecy, as to details of operation and equipment used, became generally the only possible protection. At the same time the cost of acquiring operating plant knowhow, both in refineries and for chemical plants, increased enormously. Expensive pilot plant operations were usually required, with the result that protection by patents, and secrecy as to unpatentable details became of greater importance than ever before.

*Consulting chemist.

Cost of Research

The term research is used here to include not only laboratory research but the whole development up to commercial production. This obviously may include much work of an engineering nature, and sometimes considerable investigation as to uses of products. In this connection it is of interest that the new patent law of 1952 recognizes that a new use for a product, not necessarily new itself, may be patentable in the form of describing a process embodying the new use.

Cost of research has increased in recent years not only because of the greater man power and greater output of results required by accelerated rate of progress and competition, but also as a result of the kind of projects undertaken. Many new projects require groups or organized teams numbering from half a dozen to a hundred or more; pilot plants frequently cost in excess of one hundred thousand dollars exclusive of cost of operation.

The story has often been told that when Dr. William M. Burton first arrived at the Standard Oil of Indiana plant at Whiting he was asked if he had brought his working kit with him. Many refinery laboratories of 30 years ago had only the simplest apparatus for routine testing. Now a single instrument, for example a mass spectrometer or infra-red spectograph may cost as much as the entire laboratory equipment of many refineries of that day. Although the high excess profits tax and the practice of charging research to expense, now barred by a recent Internal Revenue ruling, has recently added millions of dollars to research, there were many excellently equipped and staffed laboratories in the oil industry before World War II. In addition to those shown in the accompanying illustrations many others might be mentioned including particularly the Esso Research Center at Linden, New Jersey, the Socony-Vacuum Laboratories at Paulsboro, New Jersey, Shell Development labora-

The accompanying article is No. 4, and last, of the series by Dr. B. T. Brooks, presenting the overall picture of petroleum and petrochemical technology and the breath-taking strides taken in recent years in advancing along all fronts.

This article shows how all-important is our patent system, in protecting inventors in exchange for releasing of their often hard-won data for enriching our technical literature. This series is considered to be the most authoritative coverage of the subject yet published in a petroleum or chemical journal.

The first three of these articles are as follows:

"Renaissance of Petroleum Processing," The Petroleum Engineer, January 1954, Page C-52.

2. **"Research Foundations of Modern Petroleum Processing and Chemical Manufacture," The Petroleum Engineer, February 1954, Page C-5.**
3. **"Competitive Raw Materials and Processes for Petrochemicals," The Petroleum Engineer, March 1954, Page C-9.**

—Editor.

EXCLUSIVE

tories at Emeryville, California, Stanolind laboratory at Tulsa, Oklahoma, and many fine research facilties of chemical companies active in the field of petrochemicals including particularly that of Dow Chemical Company at Midland, Michigan, and Freeport, Texas, the duPont Company at Wilmington, Delaware, and the American Cyanamid Company at Stamford, Connecticut. These research centers also require costly libraries.

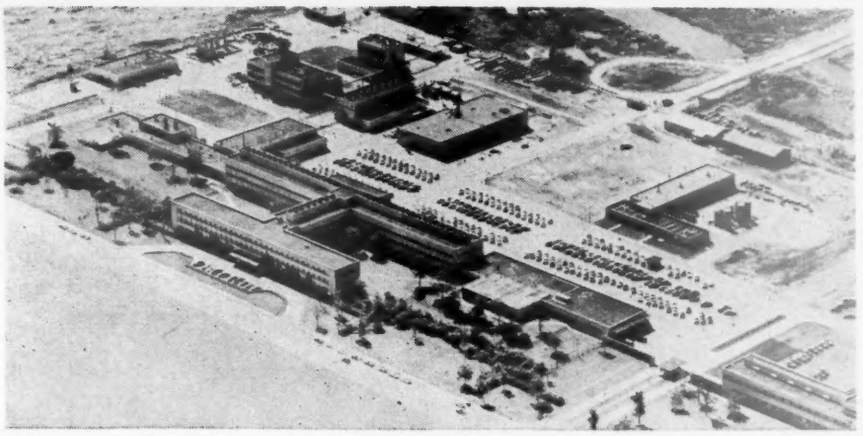
Cost of modern research and development in the fields of petroleum refining and petro-chemicals certainly should be taken into account when considering what might be a "reasonable royalty" for license of patents.

Reasonable Royalty

Last year Federal Judge S. J. Ryan, in his decision in the government's anti-trust action against the duPont Company and Imperial Chemical Industries denied a request of the government counsel for compulsory, royalty-free licenses of the patents involved, including the Polyethylene and Nylon patents, on the basis that this would destroy the value of the patents. In this connection the court noted that the duPont Company is spending about $45,000,000 annually on research and had spent about this much in developing Nylon. The court preferred not to destroy the incentive for research. The ICI had licensed the duPont Company under the Polyethylene patents and the latter company had sublicensed the Carbide and Carbon Chemical Company under these patents for an initial payment of $500,000 and royalties of $725,075 were paid by Carbide for the production of 30,200,000 pounds of Polyethylene since January 1946.

The court did order the licensing of the patents involved in the suit for a "reasonable royalty," and also ordered that the company fully reveal its know-how relating to the process covered by the patents in question.

The courts have apparently set no precedents or laid down rules such as to clarify what a reasonable royalty may be or how such a figure may be arrived at. The amount of such a royalty would certainly vary in different cases. In this connection it should be noted that charging all the royalty the traffic would bear went out of fashion in the petroleum industry around 1930 after the maze of cracking litigation was largely cleared up by cross licensing of the patents owned by the principal companies concerned. Some of the larger companies take out many patents largely for their own protection and to have a finger in the pie when it comes to the formation of cross-licensing groups. Companies having such a policy do not usually look to patent royalties as a major source of their revenue, but there is some indication of change in this respect in a few cases.



Research laboratories of Standard (Indiana), at Whiting.

Sinclair Refining recently assembled its research, experimental, and development groups in these headquarters near Harvey, Illinois.

Reasonable royalties have been ordered in other anti-trust cases.

In an anti-trust action against General Electric Company the court ordered (1953) the company to dedicate to the public all of the company's incandescent lamp patents, to allow royalty-free use of machinery for making light bulbs and to grant licenses at "reasonable royalty" under incandescent light patents developed during the next five years.

In 1945 the Supreme Court approved compulsory licensing at reasonable royalty in the Hartford Empire case, but this court has never ruled on whether or not a company can be ordered to dedicate its patents to the public or grant royalty-free licenses.

The Aluminum Company of America had made a royalty-free cross licensing arrangement with the Reynolds and Kaiser companies, but in 1950 the licenses to Alcoa were ordered canceled by the court, which had the effect of compelling Alcoa to give royalty-free licenses to these two competitors.

It may be noted that the cases noted above were anti-trust actions where, in the opinions of the courts, the patents involved were used as instruments in setting up monopolies of a kind which were the cause of the anti-trust suits. These cases therefore do not necessarily reflect any hostility of these courts to our patent system or any infection of socialistic virus.

It is also a fact that bills have repeatedly been introduced in Congress in recent years that have included some form of compulsory license provision for patents. It is well known that the voluminous literature of Marxism and that of the more militant perverters of this philosophy is full of hostility to any form of temporary monopoly or privilege deriving from patents. Many however, are of the opinion that such sniping at our patent system has been due to ignorance rather than to the influence of socialist or communist thinking. All of these bills have been defeated or died in committee.

That ignorance may be the common

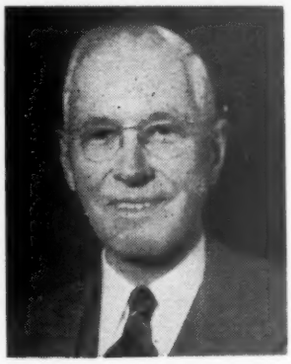
denominator of much of the hostility to our patent system as well as the spleenic ideas of the left wingers is illustrated by the comment of a professional writer and gentleman communist regarding the Dow Chemical Company. He was vehemently indignant over the fact that this company had been granted a "government protected monopoly" through patents for making metallic magnesium from salts derived from brines or "God-given sea water." He was planning to publish a fiery attack exposing this horrible situation and I told him I would help him by giving him the price history of this metal if he would promise to include the data in his article. The result was he wrote something about Saccho and Vanzetti, instead.

Outside of the decrees in the anti-trust cases noted above a reasonable royalty is whatever an inventor or a company owning a patent may determine, in fact it doesn't have to be "reasonable" at all. The Constitution delegated to Congress the power to promote the progress of science and the useful arts "by securing for limited times to authors and inventors the exclusive right to their writings and discoveries." This right is not abrogated or curtailed by corporate ownership so long as anti-trust or other laws are not violated. An inventor or a company may set a royalty figure so high that a competitor would labor under an impossible disadvantage, and this is sometimes done. If an inventor or company values royalties as income, however, or fears that too high royalties may stimulate the search for alternatives or new rival inventions, then the decision normally would be to fix the royalties at "reasonable" or safe rates.

Cross Licensing of Patents

The reasonableness of cross licensing patents grows out of the fact that research is such a wide spread activity and one inventor or one company group of patentees can seldom monopolize a new field of development. Although there have been conspicuous exceptions such as one or two patents of great importance, a single patent cannot be relied upon too much to provide adequate protection. It often happens that one research group does not think of all the possibilities or cannot explore all of the possibilities before others discover what is going on and start research along similar lines.

Those familiar with the race for improvements in the art of thermal cracking will remember the cross licensing of patents relating to the more important advances which were of inestimable advantage to all concerned. This washed out much expensive pending and threatened litigation and enabled all those who had important elements to contribute to the common pool, to use all the valuable features of all the patents. This was largely due to the wisdom and negotiating skill of Richard J. Dearborn. As a result of the formation of what was commonly called the Patent Club, however, the government brought an anti-trust suit against Standard Oil of Indiana. In this case (283 U.S. 163) the court found (1931) that "no monopoly or restriction of competition in the business of licensing patented cracking processes resulted from the execution of these agreements." The court did not sanction or condemn the practice of cross license.



R. J. Dearborn

Richard J. (Dick) Dearborn, patent and development leader of the last half century, who was largely responsible for cross-licensing thermal cracking units, while an executive of The Texas Co.

Later, when the polymerization of gaseous olefins to gasoline became important, the companies that had taken a major part in the development cross licensed their patents. Also early in World War II the companies having important patents for making high octane alkylate, cross licensed their patents and fully exchanged their know-how. This was encouraged by P.A.W. and a "reasonable royalty" for others was also approved. A similar exchange of patent rights and know-how was carried out in the case of synthetic rubber processes.

Know-How

As noted above, know-how has crept into recent court decisions affecting patents. As mentioned above, a large part of the cost of a new development is in pilot plant work and acquiring good process know-how. In many cases much of the profit of an operation lies in attaining the maximum economic result. In organic reactions the yields of desired product are often far from quantitative and a yield of 95 per cent of final purified product instead of 85 per cent will make a big difference in the profits. In many cases the yields of by-products are substantial and uses may have to be discovered for them. Process and apparatus improvement normally go on for many years and the sum total of skill and knowledge thus accumulated becomes know-how of great value. Yet from the standpoint of the protection of a new development this is often outside the field of possible patent protection.

For example, a company that had recently developed a very important new petrochemical process and had several issued patents relating to it, was asked to have the process described by one of their technical staff, for publication. A company official replied that although they had what they believed to be good patents, all they really had to license was know-how.

A similar situation is presented by the manufacture of exceedingly pure silicon. It is believed that all of the good methods for making this element have been known for some time, and the accumulated knowledge and skill gained in securing very high purity constitute the only real protection for the manufacturer.

Cases referred to above, in which the court ordered disclosure of know-how, are too recent to show how these particular orders will be carried out. In such cases it is difficult to see just how such court decrees will be carried out unless the scope of the know-how can be defined. Broadly, know-how begins at least as far back as the technical training of the engineers and chemists who develop and operate a particular process. More specifically, process know-how may consist in the precise operating conditions, possibly within the broad coverage of one or more patents, which give the maximum economic result. Such conditions may not necessarily give the maximum yields of the desired product. For example in thermal cracking the most economic operation is to limit the amount of cracking per pass so as not to deposit coke in the heating tubes. Also in the conversion of acetone to ketene by pyrolysis the highest ultimate yields are obtained by taking a relatively low conversion per pass and recycling unchanged acetone.

A considerable amount of know-how relating to the design of petroleum and petrochemical process equipment is possessed by experienced engineering design companies which knowledge is largely outside the range of patent infringement difficulties and which has been of very great value to many companies, particularly to new or relatively small companies. These engineering design firms are generally most scrupulously ethical as to passing on process information learned from one client to

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another. But it is inevitable that in designing many plants, which is often their full responsibility, their accumulated know-how as to conventional engineering problems, selection of the best materials of construction for particular services and the like, their experience is of great value. Even the largest refineries and chemical companies, with competent engineering staffs of their own, frequently make use of engineering design specialists.

In an effort not to disclose valuable know-how, however, some chemical companies do their own designing and then buy single pieces of equipment from separate fabricators, so that no outsiders possess drawings of any ensemble of apparatus.

Patents vs. Secrecy

One of the basic reasons for the establishment of our patent system was to induce an inventor to give a full and complete disclosure of his invention, in return for an "exclusive right" to his invention for a limited time, 17 years. If patents could always be relied upon to give satisfactory protection there would be little justification for secrecy and barring technical publication.

But the situation is not so simple. Patents can be invalidated or infringement determined only by due judicial process, and there has been little ground for criticism of our Federal Courts for lack of integrity. The subject matters in dispute, however, are often highly technical and even the basic term, invention, has been hard to define. The criterion of a "flash of genius" applied by the Supreme Court as a test of invention, has been superseded by the Patent Law of 1952. There is often uncertainty because of the complexity of the issues involved and also the record of the Supreme Court for a time seemed to indicate a tendency to invalidate patents.

Patents are necessarily public disclosures of their subject matter. Scientific and technical publications, however, usually go much beyond the patent disclosures. Many technical articles also reveal much essential know-how. One might assume that if the covering patents are valid and give adequate protection then technical publications cannot jeopardize the company interest. If the protection afforded by the patents is questionable, however, then the cost to a competitor's independently acquiring the know-how may be a serious deterrent. Secrecy of unpatented know-how can be a good second line of defense. But companies who rely upon secrecy rather than the protection afforded by patents should realize that what has been worked out by one group of technical men can be discovered by others. This is only a question of reasonably competent technicians, time and money. At best secrecy can be relied upon as protection only for a very limited time, far short of 17 years.

Many companies, probably the majority, rely upon the coverage and validity of their patents and have a liberal policy regarding the publication, subsequent to issue of the patents, of scientific and technical papers.

Many developments in modern refinery and chemical technology, however, are so extensive in scope and require so much research that it is impossible for the technical staff of a single company to cover all the possibilities in a few years. This means that as a result of the effort to get patent protection, with early filing dates, it is inevitable that within a very few years the patents in question begin to appear. In such cases the issuance of patents serves just as effectively as technical publications to reveal the development that is in progress.

Such situations have sometimes led to the risky practice of filing large numbers of patent applications on ideas clothed in plausible language, covering all the conceived possibilities, long before the experimental program can be carried out. During the race for patents on improvements in thermal cracking one company was reported to have had more than 1100 patent applications in the Patent Office.

More often the same background of scientific and technical knowledge which may have inspired the first invention of a series will also inspire a number of other equally intelligent and inventive people, resulting in patent interferences and perhaps ultimately in the cross licensing of patents.

There remains the question of the publication of fundamentally scientific research. There can hardly be any denial of the fact that many discoveries and inventions get their inspiration from some bit of fundamental science or published theory. All research relies heavily, and necessarily, on the great mass of published science. In the previous article in this series, Thomas Midgley, Jr., was quoted as saying, "There must be more and more fundamental research."

With the building up of well trained research staffs working in well equipped laboratories, it was inevitable that much work of a fundamental scientific or theoretical value would be done in industrial laboratories. Our crowded scientific journals bear witness to this fact. In fact it is very doubtful if industrial research can now be carried out without obtaining such results. This is inherent in the method of such research. Though there may be some small risk in publishing such work, the company that withholds scientific publication, after reasonable patent protection has been secured, would be shortsighted and selfish indeed.

It is not likely that caution and secrecy will curb scientific publication to the extent of curtailing the volume or impairing the quality of our scientific and technical journals. Approximately 85 per cent of the research papers presented to meetings of the American Chemical Society are not published. Some of these papers probably do not merit publication but the Journal of this society is compelled to limit authors to highly condensed articles. Other technical societies find it increasingly difficult to cope with the ever greater volume of scientific and technical contributions.

One class of information is freely published by all companies, i.e., material describing the products sold and special uses for which they may be adapted. Also many patented processes are most fully described in cases where companies desire to license them at satisfactory royalties. This has been true, for example, of cracking processes for many years, down to the latest types of catalytic cracking units. One company that was very active in the cracking development, the Universal Oil Products Company, published scores of technical articles, mainly relating to their processes, and for many years issued reprints of these papers as company bulletins. This company also publishes a valuable abstract bulletin covering generally the field of petroleum technology. It is evident therefore that the protection derived from patents sometimes is a stimulant to technical publication.

It may be noted too that many patent attorneys, both patent counsel for companies and in private practice, have had considerable technical or research experience. They understand the point of view of both the research worker and engineer and the company management. They should be, and frequently are, represented on the publications committee of their companies.

The above discussion may be summarized by stating that the patent policy pursued by the great majority of petroleum and chemical companies, the great number of patents being issued annually, the general fairness of patent litigation, and the great volume of technical publications from industrial laboratories, shows very clearly that our patent system works very well and fulfills the purpose of the original constitutional provision of inducing inventors to make full and complete disclosures of their inventions and related discoveries in return for patent protection for a limited period of time. *

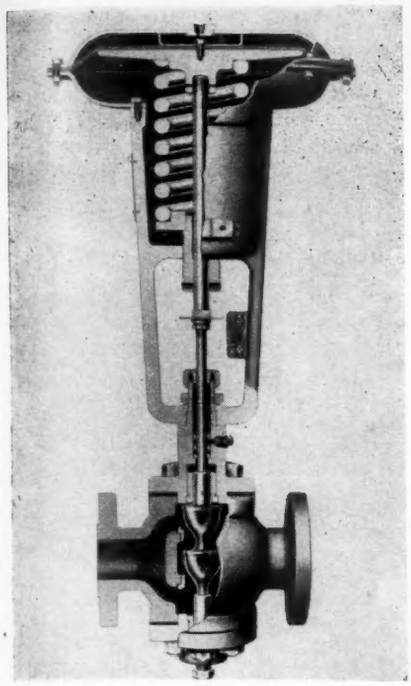
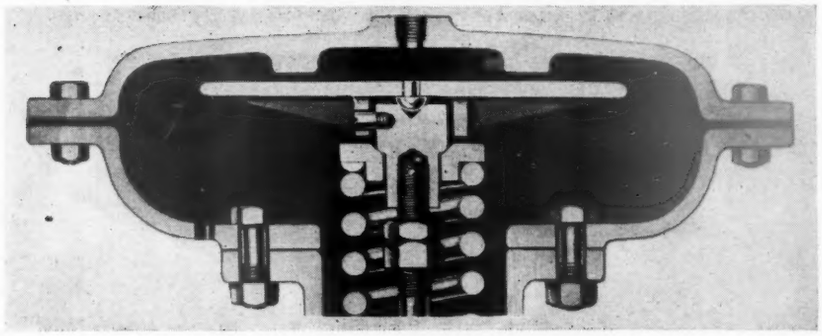


FIG. 1. CUTAWAY drawing of a typical diaphragm motor valve.

FIG. 2. CROSS-SECTION of the power or motor (diaphragm) head of a motor valve.



Part 13

TRENDS IN REFINERY INSTRUMENTATION

Principles in design and operation of diaphragm motor valves

W. C. LONGSTRETH and S. D. ROSS*

THE growing importance of automatic control in the petroleum industry has created a need for valves suitable for use in a wide variety of applications. No longer is a valve considered a mere mechanical gadget to be inserted at random in a length of pipe to shut off the flow of the fluid. It is now a carefully engineered element, to be used with other elements in a complete system known as the control loop. It is designed for use with the primary measuring element, controller, and other control accessories, each of which is carefully selected for the service it is to perform.

Various types of valves are used in the petroleum industry. Among them are gate, butterfly, globe, hand control, internal pilot, and automatic control valves. Automatic control valves can be pneumatically or electrically operated, electric operation being either by means of a solenoid or an electric motor. The large majority of automatic control valves, however, are diaphragm motor operated, and this article is confined to a discussion of devices of that type.

Diaphragm motor control valves, Fig. 1, are composed of two main units —the diaphragm motor, which converts air pressure into motion of the valve stem, and the valve proper, which is basically a variable orifice, regulating the flow of a fluid in accordance with the motion of the valve stem. The diaphragm motor has two essential elements—the diaphragm, Fig. 2, which exerts force on the valve stem, and a spring, Fig. 3, to exert a force opposing the motion of the valve stem. Air pressure from the control instrument, applied to the diaphragm, moves the valve stem until the increasing force exerted by the spring under compression arrests the motion.

The spring has an almost linear force-deflection curve, so that the motion of the valve stem is practically proportional to the applied air pressure, but the design of the valve body and inner valve determine the flow characteristics. The pressure span of controlled air ordinarily used is 3 to 15 psi. At three pounds, the stem will begin its travel, while at 15 psi, its entire traverse will have been completed.

Single-Seated Valves

Diaphragm motor valves may be divided roughly into two general classifications — single-seated, Fig. 4, and double-seated. Tight shut-off valves are practically always single-seated, as it is almost impossible to maintain close contact between both flanges of a double-seated inner valve and both valve seats under conditions of changing temperature, due to the difference between expansion coefficients of the metals used for the valve housing and the trim.

Single-seated valves of the globe type are also used in on-off control, where throttling is not required, and the amount of valve stem movement is not critical. In this form of control, the speed of opening and closing is the matter of prime importance. Air pressure changes from minimum to maximum, or maximum to minimum, when the control instrument pointer reaches

*Brown Instruments Division, Minneapolis-Honeywell Regulator Company.

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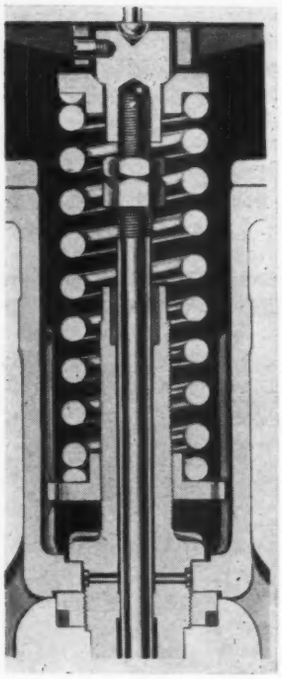


FIG. 3. ACTUATING spring section of a motor valve.

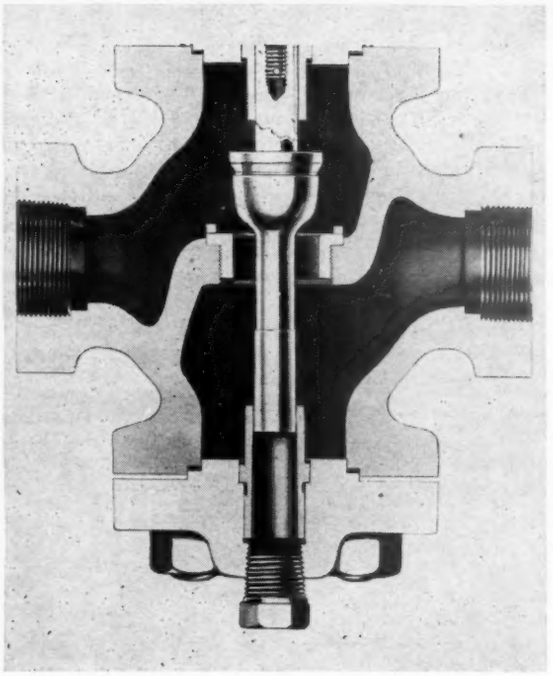


FIG. 4. MOTOR valve having only a single seat.

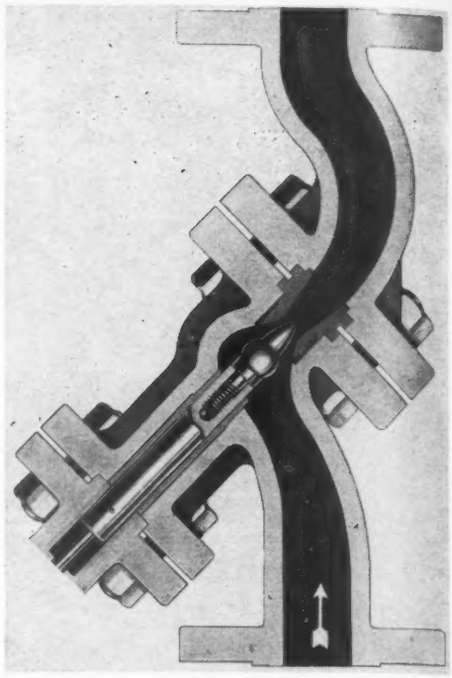


FIG. 5. ANOTHER type of single-seated valve, known as the angle or Venturi type.

the set point, and the valve stem travels from the position of fully closed to that of fully open without delay.

Single-seated valves are used for throttling control to a limited extent. In such applications, the valve body is generally a streamlined Venturi or angle type, Fig. 5, and the plug is small in size compared with the pipe size. This is due to the fact that a large plug, with fluid pressure acting against it in one direction only, could not be positioned accurately by a spring-opposed diaphragm motor.

Single-seated throttling control valves of the Venturi type, however, offer distinct advantages in certain applications. Due to the shape of the body, the change in direction of flow is reduced to a minimum. Where double-seated valves are used with high-temperature high-velocity vapors, or liquids with entrained solids, the repeated changes in direction cause impingement of the fluids on the inner parts of the valve, which results in erosion and cavitation. These alter the flow characteristics very rapidly, and finally destroy valve body and trim. Vibration and noise are also produced. Single-seated Venturi valves are much less affected by these conditions.

Single-seated proportional valves are occasionally made in sizes as large as six inches, to meet severe requirements. In the large sizes, a valve positioner is always required.

Double-Seated Valves

Double-seated valves, Fig. 6, are used almost exclusively in throttling control. The valve body has two seats, with their centers on the same axis, with an inner valve, the flanges of which, in the fully-closed position, rest on both seats.

The fluid enters the valve body through an inlet between the two seats and divides, part passing through the upper orifice and part through the lower. As the openings are very nearly of the same size, and the force exerted by the fluid entering the body is applied to the plug in two opposite directions, valve stem movement is little affected by the fluid flow, and the position of the inner valve is governed by the control instrument air pressure and the opposing force exerted by the spring.

There is a slight difference in the sizes of the two seats. This is due to the fact that after one seat ring is removed, the opening remaining must be large enough for the other ring to be removed or replaced through it. The difference in size, however, is not great enough to cause a large unbalance in the opposing fluid forces.

Inner Valves

Inner valves are of several forms, to give the flow characteristics required for various applications. They can be made in V-port, shown in Fig. 6, or contoured types, Fig. 7, to give flow-lift characteristics which have linear or equal percentage characteristics. V-port inner valves are generally skirt-guided, while contoured plugs are always stem-guided.

Contoured inner valves must be machined to very close tolerances in order to give flow characteristics for which they are designed. Because the shape is critical, they can lose their

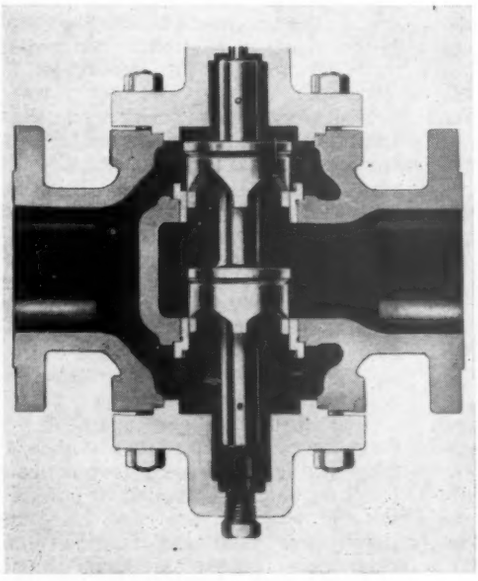


FIG. 6. DETAILS of a double-seated control valve.

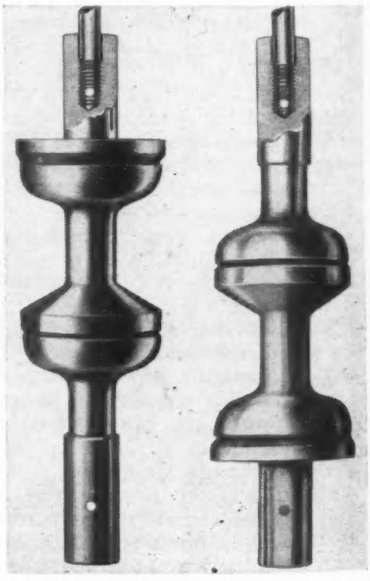
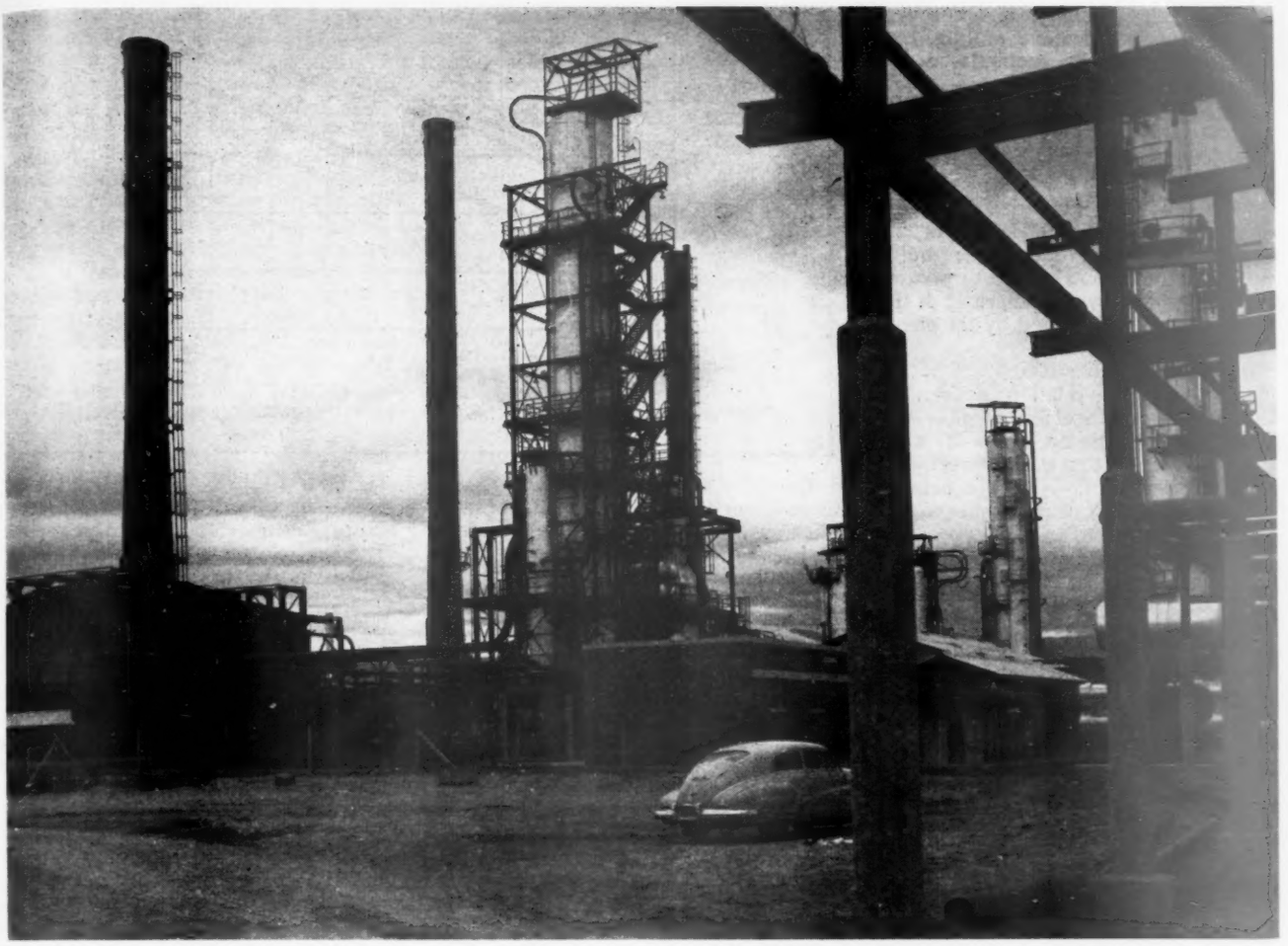


FIG. 7. TYPES known as "contoured inner valves."



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characteristics quickly under severe service, especially where scaling, corrosion or erosion are encountered. Because of their small clearance at low lifts, they should not be used to throttle liquids carrying suspended solids or coking materials.

Flow Characteristics

The most important factor in the performance of a diaphragm motor valve, from the point of view of process control, is the flow characteristic of the valve. This is determined by the shape of the inner valve.

The term "valve characteristic" is used to denote the relation between the amount of stem travel and the flow, under constant pressure drop. It is of great importance that the valve selected have the correct flow-lift characteristic, taking into consideration the extent of the expected load changes, and stability requirements.

In Fig. 8, Curve A-2 shows the flow-lift characteristic of an equal percentage V-port inner valve, while curve B-2 is the characteristic of an equal percentage contoured inner valve. In these, equal changes in valve stem position produce a flow change which is an equal percentage of the flow rate before the change in stem position was made. The new rate of flow will vary with the portion of the valve stem travel range over which the change in position was made.

Curve B-3 is the characteristic of a linear contoured inner valve. In this, equal volume changes in flow result from equal changes in stem lift, regardless of per cent of valve opening. The flow-lift curve is approximately a straight line on rectangular coordinates. Note that the linearity is not maintained under conditions of very low flow.

Ratio of the maximum controllable flow to the minimum is known as rangeability. It depends on the shape of the plug.

A variety of inner valves is available, having widely differing curves of flow vs. stem position. In certain cases, proper selection of the characteristic makes possible, or at least simplifies, close regulation of the process. In other cases, the characteristic is found to be relatively unimportant.

The curves shown in Fig. 8 were obtained under conditions of constant pressure differential across the valve. They are known as "inherent valve characteristics." When a valve is installed under actual conditions where the pressure differential is not constant, the curve is modified. It is then known as the "effective valve characteristic."

Three-Way Valves

Another form of diaphragm motor valve is the three-way, Fig. 9. Widest uses for this are in diverting and mixing services.

There are three connections in the same plane, but spaced at 90-deg intervals. When used as a diverter, the fluid enters one inlet, and is divided between two outlets. When the inner valve is in either of its limiting positions, all the flow is diverted to one of the outlets.

In mixing service, fluid streams enter the valve by two inlets, and after mixing, leave by the third outlet. The fluids are mixed in proportions depending on the position of the inner valve.

Three-way valves are made in both single-seated and double-seated types. In either case, they are opposite-acting so that as one port closes, the other one opens. They are designed so that orifice areas are interchanged; that is, if one orifice is opened 25 per cent, the other is 75 per cent open. The sum of the orifice openings is always 100 per cent.

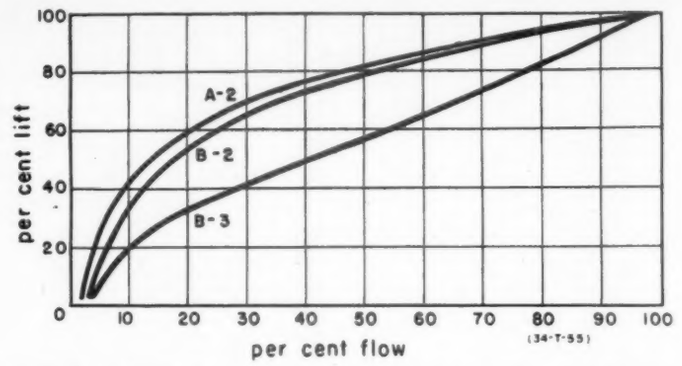

FIG. 8. FLOW characteristic curves of types of double-seated valve.

Saunders Type Valve

Among the control valves for special applications is the Saunders type, Fig. 10, for the control of slurries, liquids with entrained solids, and corrosive liquids.

A flexible diaphragm serves both as valve disc and packless stem seal. The interior of the body can be lined with rubber, glass, lead or Saran, while the diaphragm can be of rubber, elastomers or any flexible plastic. Tight shut-off is provided, even though solids may be lodged on the valve seat.

The diaphragm area is large, compared with the inner valves of other types. Consequently, large operators must be used. The temperature range is limited to — 80 to + 350 F.

These valves have low pressure drops, but poor control characteristics. Their resistance to corrosion, however, and tight shut-off characteristics have made them standard equipment for certain difficult applications.

Diaphragm Motor Operation

Diaphragm motor operation of valves can be either air-to-open, in which the movement of the valve stem due to increasing air pressure opens the valve, or air-to-close, in which the increase in air pressure closes the valve. The basis for the selection of the method of operation depends on which will cause the valve to fail safe in the event of failure of the operating air supply.

If the application is heating, by means of steam or other hot fluid, operation should be air-to-open. Then, if the air supply fails, spring pressure will close the valve, and prevent damage due to overheating. If, however, the application is cooling, by means of a circulating fluid, the valve operation should be air-to-close. In this case, if the air supply fails, spring pressure will open the valve, allowing a maximum flow of cooling fluid. In this case also, damage due to overheating will be avoided.

Valves may also be classified as high-lift and low-lift, based on the stem travel required to move the inner valve from fully-closed to fully-opened posi-

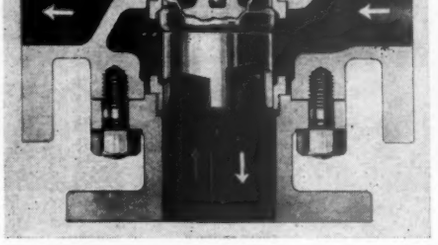

FIG. 9. CROSS-SECTION of a more complicated—three-way—valve body.

FIG. 10. CUTAWAY of a special, Saunders type of valve assembly.

tions. Low-lift valves are quicker acting, although less accurate. High-lift valves, although slower in response, can be positioned more accurately, due to the greater stem travel required to move inner valve a corresponding amount.

Theoretically, a diaphragm motor valve should have a fixed relationship between valve lift and air pressure applied to diaphragm. In practice, however, many factors tend to cause variations in this relationship. Friction, due to tightness of stuffing box, improper packing, poor lubrication, worn or corroded valve stems, poor machine work or improper assembly, is a frequent cause. Diaphragms with snap action, or which are too stiff, or poorly made springs can also cause irregularities. Even with well-designed valves, which are properly constructed and correctly adjusted, the pressure-lift relationship may not be constant. Variation in the pressure drop across the valve, especially in the single-seated type, may cause serious variations.

The combination of these defects causes hysteresis, which, in an average valve, may be as great as 2 per cent. This means that if after rising, the air pressure from the control instrument begins to fall, it may decrease 2 per cent before the motion of the valve stem is reversed. In critical applications, this would cause steady cycling which could not be tolerated. To overcome this, valve positioners are required.

Valve Positioners

A valve positioner, Fig. 11, continuously compares the stem position with that called for by the instrument air pressure, and regulates the air supply to bring the valve stem to the required position. Upon a variation in this position, a pilot valve in the positioner admits air pressure to the space above the diaphragm until the valve stem is forced down to its proper position, at which point the air pressure is shut off.

Valve positioners reduce the dead zone of the valve to something on the order of 0.1 per cent. In addition, they increase the speed of response, which can be of importance, especially when the control instrument is at a considerable distance from the valve. They also make possible accurate operation of several valves in sequence from the output of a single controller, as when one instrument must control the flows of both heating and cooling media.

Springless Valve Motors

Another type of valve operation is springless, in which air pressures are applied to both sides of the same diaphragm. Full pressure is applied to one side, and reduced pressure from the throttling control instrument to the other. The valve stem position is determined by the pressure differential. One of the objections to this system is that there is no way of causing the valve to fail safe in the event of interruption of air pressure.

Stuffing Box

Great stress is laid on the accuracy and sensitivity of control instruments, but unless the control valve is equally sensitive, it will not be possible to position the inner valve accurately. The greatest obstacle to accurate positioning is stem friction.

To minimize this, great attention must be paid to the stuffing box, Fig. 12. A packing depth equal to six stem diameters is considered good practice. Molded graphited asbestos packing is widely used, although packing rings, formed from shredded Teflon*, and Teflon-impregnated asbestos are now being used successfully. Many types of lubricants are used, with Silicones† probably the most popular. Even with the best packing and lubrication, exceptionally fine finishes on the valve stem and inside the stuffing box are required. Cooling fins are generally supplied to protect the stuffing box if temperatures exceed 450 F. For extremely low temperatures, a plain extension head is often used. It is occasionally traced with steam coils.

Materials of Construction

The materials used in valve construction vary with the service for which the valve is intended. They will depend on the temperature, pressure, and conditions of erosion, as well as the nature of the fluid which is to be controlled.

Bronze, cast iron, and steel are frequently employed for valve bodies, while stainless steel and other corrosion-resistant metals are occasionally used. The same metals are used for valve trim, but in addition, monel metal is often employed in applications involving corrosive fluids.

Other metals supplied regularly for trim, and for valve bodies on special order, include aluminum, brass, molybdenum stainless steel, nickel, nickel-iron alloys, and Stellite. Practically any metal can be supplied for trim, on special order, and valves can be lined with glass, rubber, or various compositions to increase corrosion resistance.

*Trade mark, E. I. Du Pont Company.
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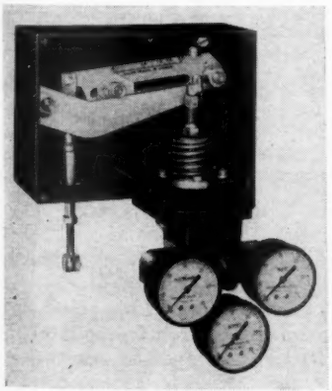

FIG. 11. WORKING essentials of a Moore Valve positioner (Courtesy Moode Products).

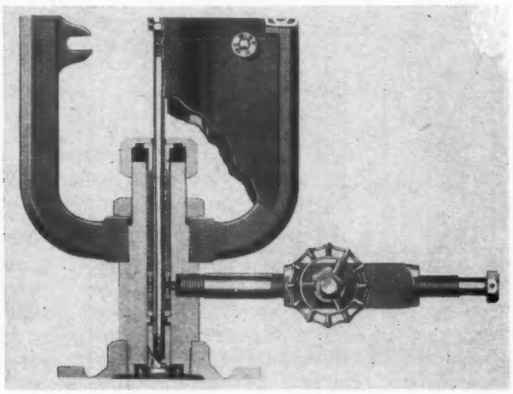

FIG. 12. DETAILED cross-section of a valve stuffing box.

Valve Sizing

No matter how accurate the control instrument, or how well designed and constructed the valve, satisfactory control will not be realized unless the valve is properly sized.

A number of valve sizing techniques are employed. Each manufacturer supplies instructions for use with his product. One of the most satisfactory, however, is the so-called "C_v" method, in which the existing conditions of the fluid, such as pressure drop, specific gravity and other variables, are first converted into a reference condition. This is the quantity of water, in gpm at 60 F, that will flow through the valve with a pressure drop of 1 psi. It is called the flow coefficient (C_v). After the existing conditions have been converted to this coefficient, valve size is found by referring to a table which shows the size corresponding to the specific C_v factor.

All manufacturers supply tables, nomographs, slide rules or other devices, together with instructions for their use in valve sizing.

Diaphragm Control Valve Maintenance

Satisfactory control depends not only on the selection of the correct valve for any given application, but also on its installation and maintenance. Plans for maintenance are considered in the design, and carried out further in the installation.

In small plants where only a few valves are installed, maintenance facilities cannot be as complete as in large establishments where hundreds are in use. But in even the smallest, a regular routine of inspection and repair should be followed, and careful records kept of all maintenance.

Whether a valve is new or has been repaired, it should be given a complete inspection before it is installed in the flow line. This should include not only a careful examination of all parts, but a check of the packing and stem lubrication. Where many valves are in use, the placing of name plates on the spring-barrel saves considerable time in identification.

Field maintenance includes the checking of packing for leaks, regulation of lubrication, and periodic checks of the stem for travel and operating position.

Reasons other than mechanical defects may require the removal of a valve from the line. It may be too large, in which case the plug will ride the seat, or too small, which will cause

it to remain wide open. The materials of body or trim may be unsuitable, in which case corrosion or erosion may result. Clay slurries have been known to cut carbon steel in 24 hours, whereas in the same application heat treated tool steel lasted for 12 weeks.

In certain larger plants "routine turnaround" is practiced. At definite intervals, valves are removed from service and thoroughly reconditioned. If the controlled fluid has been an acid, all traces of it are washed out. Needed repairs are made to all mechanical parts. Broken parts of the frame are welded, and the diaphragm is replaced if it leaks, or shows any signs of deterioration.

If contoured valve plugs show signs of erosion, they are rebuilt by welding, then turned to shape in a lathe, and finally ground to fit. After reassembly, the alignment of stem and plug is carefully checked, and the stem tested for friction. Stem movement is also checked under air pressure.

If valves require repairs at too frequent intervals, they are checked for suitability of size, design or materials for the service in which they are installed.

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* * *

New Units Planned by Esso

Esso Standard Oil Company will build at its Baltimore, Maryland, refinery, three Hydrofining units for the desulfurization and general quality improvement of naphthas and heating oil . . . and a fixed-bed Hydroforming unit for the octane upgrading of heavy naphtha. Total cost will approximate $3,500,000.

The Hydrofining (catalytic desulfurization in presence of Hydrogen) units will charge 12,000 bbl per day of straight run naphtha; 5000 bbl per day heavy catalytic heating oil (of sulfur and carbon residue reduction), and 3000 bbl per day heavy naphtha Hydroformer feed stock.

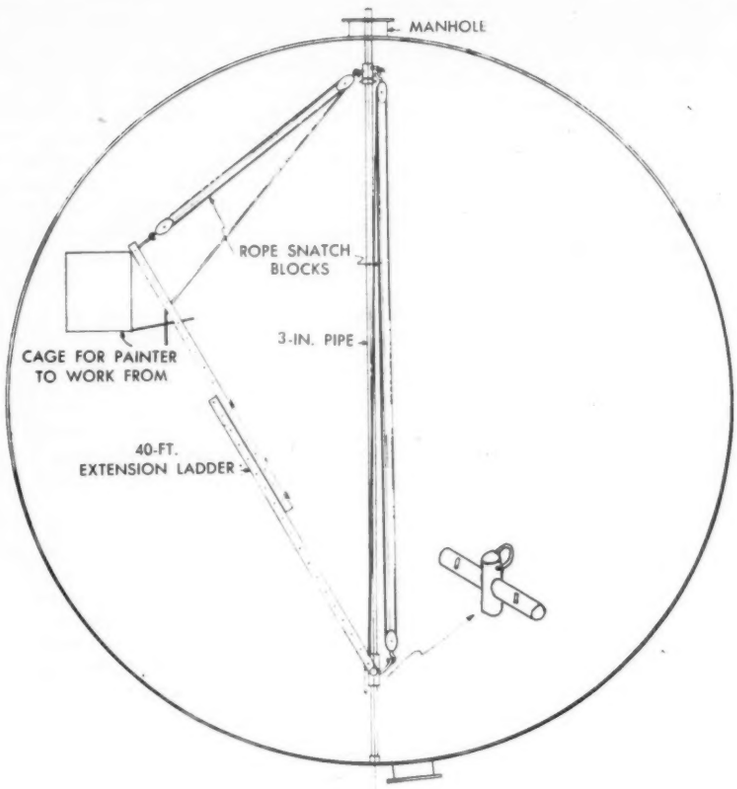
The Hydroformer will be a fixed-bed, three-stage unit with a capacity of 3000 bbl per day. By-product hydrogen will supply requirements of Hydrofining units.

Foster-Wheeler Corporation has contract for design and construction of these units.

Plant Aid

Portable Scaffold[§]

E. C. JENNINGS††



Scaffold is built on a revolving gin-pole with three adjustments for the working cage allowing complete coverage of a ball type tank with minimum time and effort.

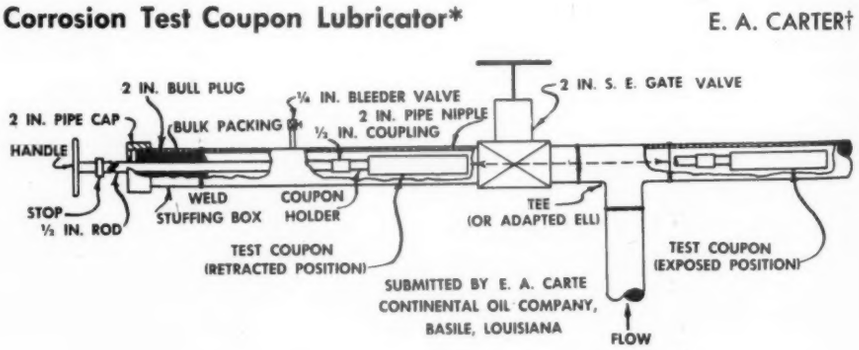
The gin-pole consists of 3-in. pipe extending through the top manhole with sleeve connections for steadiness. A sleeve is also spot welded to bottom of tank for gin-pole to pivot in. This sleeve will be left in tank for future use. Two rope blocks are required for two of the adjustments of this scaffold, a cage constructed of ¾-in. pipe with 2-in. wood floor suspended from the end of a 40 ft aluminum extension ladder constitutes the working area of blaster or painter. The pivot base of ladder (shown in detail) is made of 3-in. pipe with 4-in. sleeve to revolve on gin-pole. This scaffold is constructed for entrance to tank through a 16-in. manhole.

[§]Class C, first prize; NGAA — Panhandle-Plains Regional Meeting, Amarillo, Tuesday, November 20, 1951.

††Phillips Petroleum Company, paint foreman, Phillips, Texas.

Corrosion Test Coupon Lubricator*

E. A. CARTER†



Initial preparation for use of lubricator requires simple entrance connection for coupon into stream through a 2-in. gate valve either welded or screwed. To install coupon; pull ½-in. rod out whereas coupon will be inside 2-in. pipe; screw pipe into 2-in. gate valve; open gate valve; shove rod with coupon into line; tighten packing gland (2-in. pipe cap) to hold secure. To remove coupon: release friction on rod by unscrewing packing gland slightly, pull rod out as far as possible, close 2-in. gate valve, open ¼-in. vent valve, remove lubricator.

*Class A, honorable mention, NGAA Kinks Contest.

†Continental Oil Company, Basile, Louisiana.

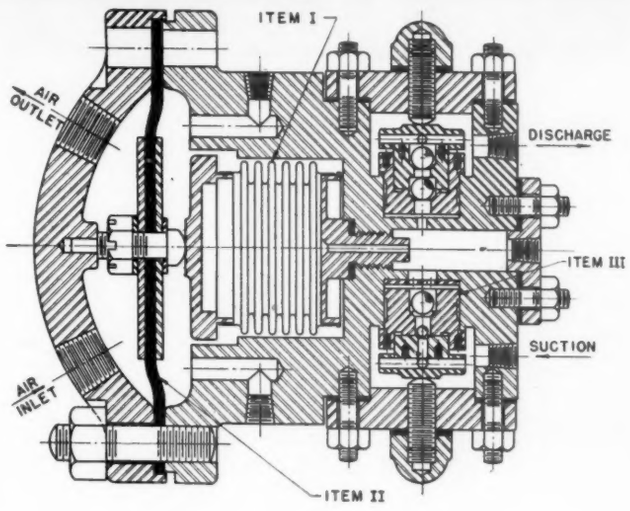


FIG. 1. Original design of sample-pump element discussed in this article.

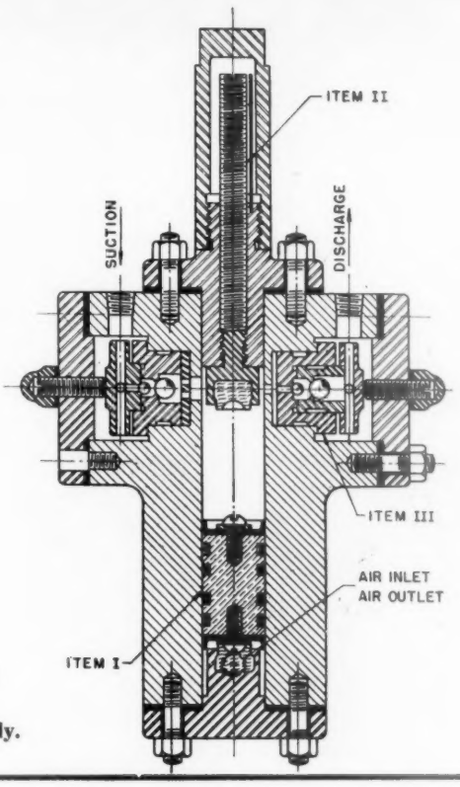


FIG. 2. Newest design of pump element, employed currently.

Improved system solves problem of obtaining composite hydrocarbon samples, in direct proportion to flow in this

New Method for Automatic Sampling of Hydrocarbons

W. E. GIBSON

Abstract

The need of an improved means for obtaining composite hydrocarbon samples has been recognized in the chemical and petroleum industry for years. This is especially true for accounting streams or for any stream requiring accurate sample control. Without any reflection upon operating personnel, the taking of such samples manually is unreliable under the best of conditions. The solution in the form of an automatic device is described.

IN the operation of the Government-owned butadiene plant at Torrance, California, by the Shell Chemical Corporation, the method of taking composite samples manually from the feedstock and recycle-accounting lines proved extremely unreliable. It was desired to obtain a 4-liter sample over a 7-day period. In some cases it was found that the sample bomb would be filled in 3 or 4 days, and in other instances no sample had been drawn off in the entire period.

In order to eliminate the human element in this operation, and assure reliable samples, the market was investigated for an automatic composite hydrocarbon sampler. Nothing was found that would meet the specifications desired by the chief chemist. These were: (1) Fully automatic and leak-proof; (2) frequency of the sample cycle in direct proportion to the line flow; (3) quantity of each sampling cycle sufficient to give a 4000 cu cm composite sample in 7 days; (4) adjustable for longer or shorter sample increments, if desired; (5) all drive equipment to be fully explosion-proof.

Automatic Sampler Design

To meet these requirements the author undertook the design of a fully automatic hydrocarbon-sampling de-

The Author

W. E. Gibson is chief inspector and project engineer for Shell Chemical at Torrance, California. He spent the first 10 of his 32 years of engineering experience in the metal mining and smelting industry in the U. S. A. and South America (Peru) as draftsman, design engineer and construction superintendent. He joined Shell 22 years ago as a design engineer, and has functioned in that field, also as project engineer and office engineer, until given his present position. He has been a part of the growth of the petrochemical industry for several years, and is well qualified to speak authoritatively on practically any phase of that phenomenally growing field.

†Presented at the annual meeting, New York, November 29-December 4, 1953 of The American Society of Mechanical Engineers.

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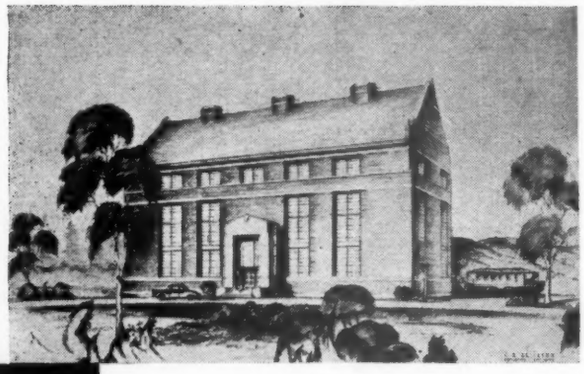

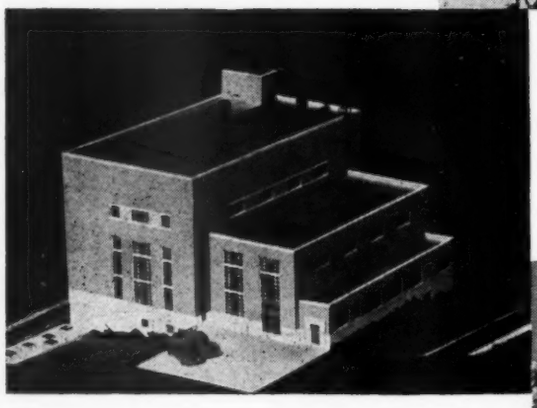

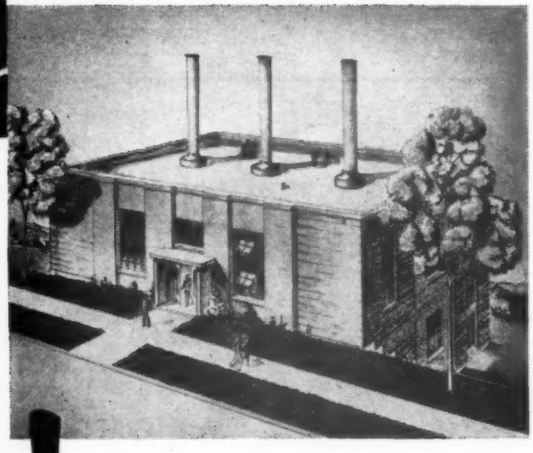

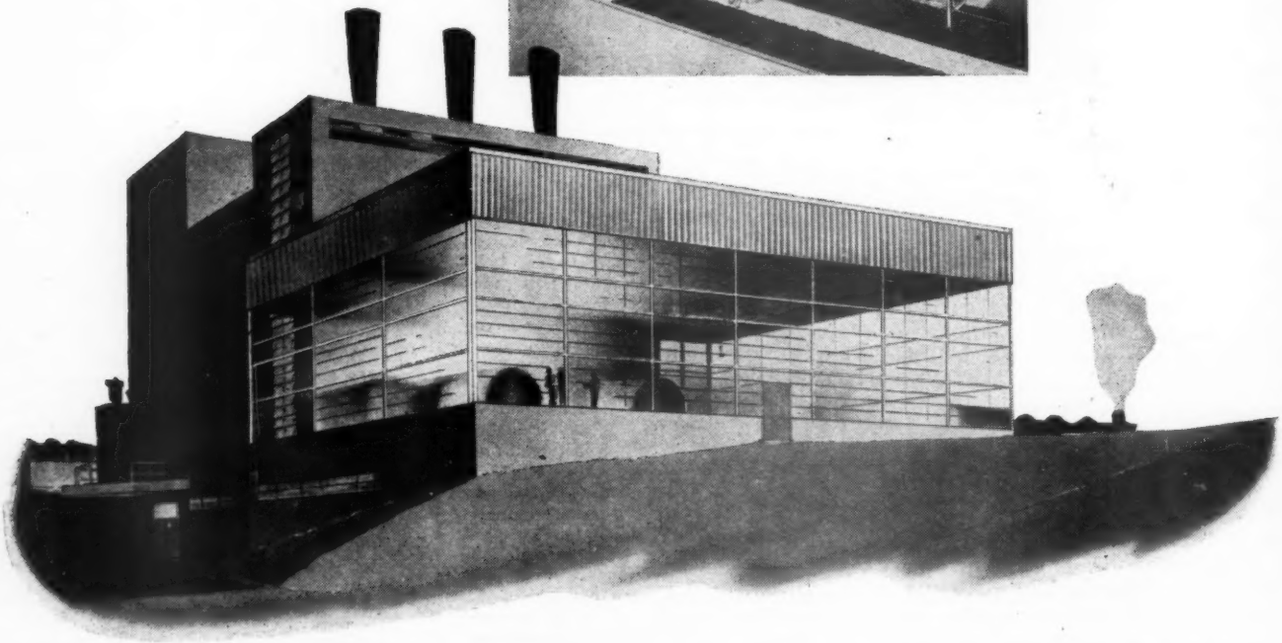

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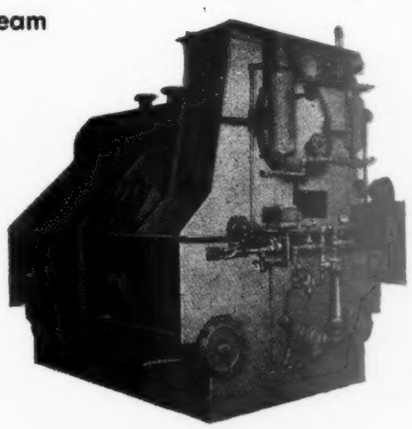

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vice. The original design of the sample-pump element is illustrated in Fig. 1. The three main component parts consist of the bellows measuring chamber and pump, Item 1; the operating diaphragm, Item 2, and the double ball check valves, Item 3. The space between the diaphragm and bellows is filled with a light grade of oil and connects to an atmospheric sight glass. This provides a means of detecting any leaks in the sampler. The quantity of the sample may be varied by changing the bellows size. The range, however, is limited to the economical design limitations of the bellows and requires dismantling of the unit with the attendant interruption in the sampling cycle. This type of sampler operated successfully for 2 years, prior to placing the plant in standby.

In order to overcome the disadvantages in this model and provide greater flexibility, a new element was designed as shown in Fig. 2. In this unit the bellows and diaphragm are replaced by a floating piston, Item 1, thus permitting control of the sample quantity while in operation by changing the piston stroke with the adjusting screw, Item 2.

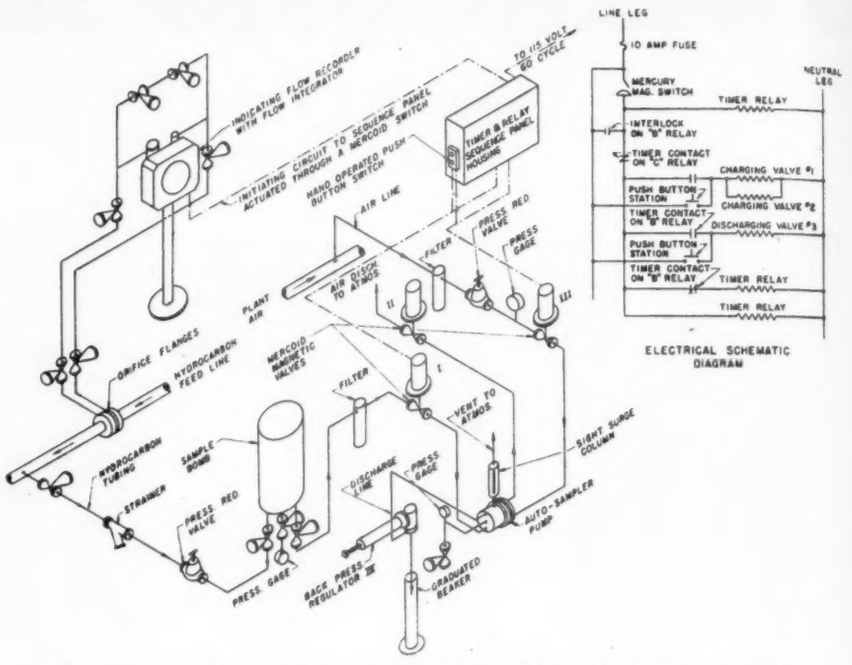


FIG. 3. Process for sampling a stream automatically, showing how sample pump is connected into stream flow line.

Manual Composite Sampling

Four-liter sample bombs are used for the composite samples. Nozzles are provided for inlet and draw-off, one of which has an insert projecting 2 in. inside the bomb.

The laboratory prepares the bombs for sampling by filling with water to the insert and providing an inert-gas cap pressured for the desired operating conditions. The sample is taken by displacing a measured amount of water from the bomb with hydrocarbon.

In manual operation the operator draws off the desired number of cubic centimeters of water per sample increment into a graduated transparent measuring tube. The graduations are in increments of 50 cu cm from zero to 4400.

Automatic Sampling

In automatic sampling a 6-liter bomb is used. Preparation of the bomb for sampling is identical with that for the manual operation. In order to avoid a hydrostatic condition developing from a leak in the vapor phase, valves are located in the liquid phase only.

The automatic operation is identical for both models of sampler. The sample pump is connected to the flow line as shown in Fig. 3. The sample connection is taken off the flow line downstream of the orifice meter and connected to the bottom of the sample bomb. Desired operating pressure in the bomb is maintained by the pressure-reducing valve in this line. Water draw-off line connects from the insert nozzle on the bomb to the suction of sample pump through the solenoid-operated valve No. 1. Discharge from the sample pump connects to the cubic centimeter-measuring tube through the back-pressure regulator valve No. 4. This valve is set to operate at a pressure of 10 psig above that maintained in the bomb.

The operating air is connected to the air-inlet connection on the sample pump through the solenoid-operated valve No. 3. The exhaust air is vented to the atmosphere from the pump through the solenoid-operated valve No. 2.

The sampling cycle is controlled in direct proportion to the flow rate in the line sampled. This is accomplished through a time-relay sequence wired as shown on Fig. 3. These relays are energized through a mercoid switch actuated by a small magnet attached to an integrating gear of the intergrating flow recorder. Therefore, the operating sequence is initiated once for every revolution of this gear and is in direct proportion to the flow rate.

The relays are set to operate the solenoid valves in their proper sequence and with the specified time lag. When the relays are energized, solenoid-operated valves Nos. 1 and 2 open immediately, admitting a charge of water from the bomb into the sample pump and venting the air chamber to the atmosphere. Throughflow to the measuring tube is prevented by the back-pressure regulator valve No. 4. After the preset time lag, these valves close and the solenoid-operated valve No. 3 opens admitting the operating air to the air chamber, forcing the measured quantity of water into the measuring tube, thus completing one sample cycle. This air pressure is maintained at a pressure 10 to 15 psig above that of the back-pressure regulator valve No. 4.

The operating cycle is approximately 20 min, depending upon the flow rate, and the volume of the sample pump is set to give approximately 3800 cu cm in 7 days.

With this sampler we have been able to obtain reliable composite samples over an operating period of 4 years. The bellows type has been retired in favor of the more flexible floating-piston type.

Although this sampler was designed primarily for hydrocarbon service, it could be adapted to other liquids by use of a medium in the sample bomb not soluble with the sample. It also could be used to pump directly into the bomb by proper valving and controls.

Acknowledgments

This work was performed by Shell Chemical Corporation, as agent for the Reconstruction Finance Corporation in the operation of a butadiene plant in the Government Synthetic Rubber Program.

The necessary clearance for publication of this paper has been obtained from both the Office of Synthetic Rubber and Shell Chemical Corporation. ★

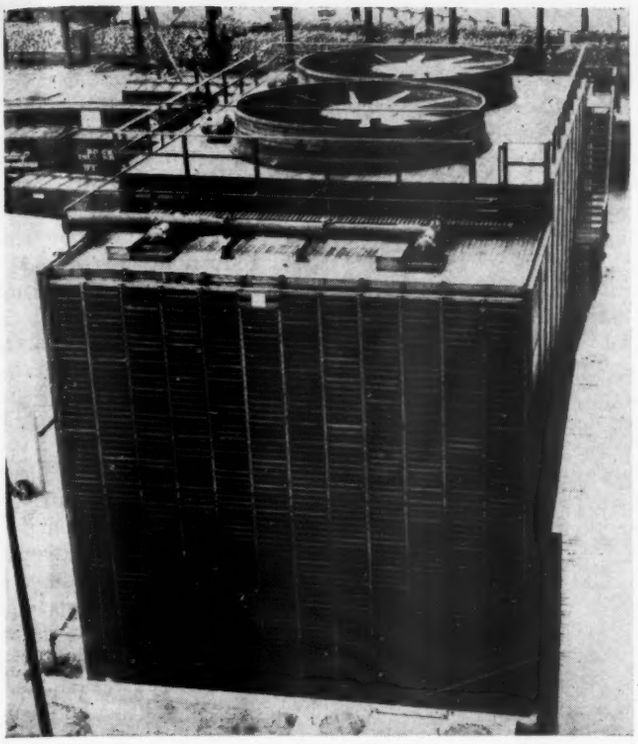


FIG. 1. A typical cross-flow industrial cooling tower of 18,500 gpm capacity; note twin fans with their motor drives, and open, hot-water distribution system.

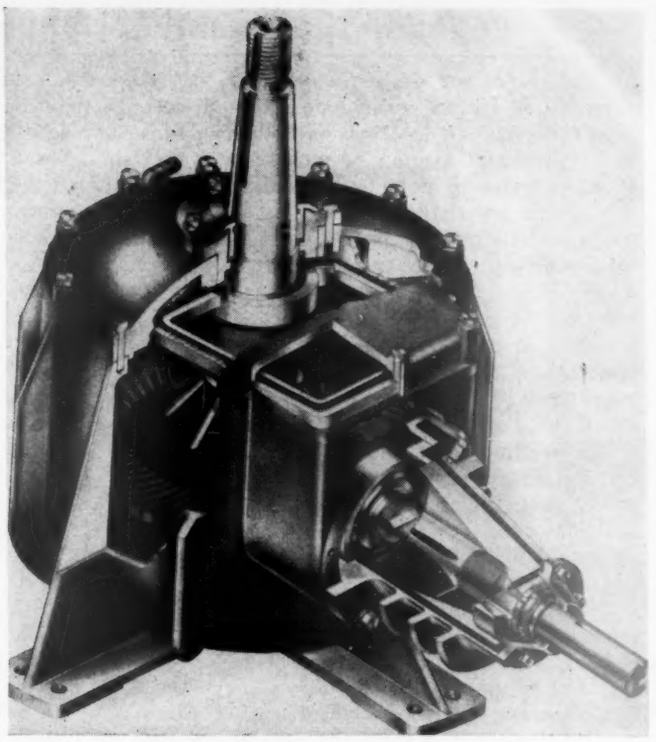


FIG. 3. Speed reduction unit, mounted between fan and driving motor.

Industrial Cooling Towers—Part 3

Materials, Mechanical Equipment and Preinstallation Considerations

Redwood, fans, speed reducers, sound, pumps, and tower placement

HOWARD E. DEGLER*

VARIOUS materials have been used in cooling tower construction, but California Redwood is used almost exclusively in this country for industrial towers. In foreign countries, cedar, fir, mahogany, or other native woods have been used; large chimney type towers of concrete are used in Europe. Asbestos-cement board, plastics, aluminum, stainless steel, and galvanized steel have been used for the casing, louvers, eliminators, splash bars, and fan blades, especially in the medium and small-capacity units.

California Redwood for Cooling Towers. Redwood lumber has many remarkable qualities. Nature has impregnated this wood with a natural preservative, making it very durable and resistant to decay, insect attack, and alternate wetting and drying. It possesses comparatively high-strength properties and, since it contains no pitch or resin, is highly fire resistant. Redwood weighs about 28 lb per cubic foot, has low shrinkage properties with little tendency to warp or split and is particularly useful for outdoor structures. Many years of service have proved the worth of redwood for the building of water-cooling towers.

Redwood Design Characteristics for Cooling Tower Structures. Allowable tension and compression working stresses are calculated from the tabulated basic stresses in Table 1 by the

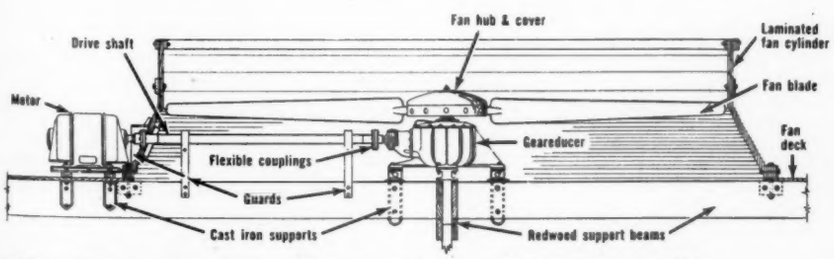


FIG. 2. Line drawing of a fan-drive assembly for an induced-draft cooling tower, showing fan-reducing gear, drive shaft, cylinder and supports.

*The Marley Company.

EXCLUSIVE

application of a "grade factor" and "application factors" to include allowance for use in wet locations and other than permanent loading of members. Wind pressure in pounds per square foot should be calculated from the following equation for rectangular buildings when wind velocity in miles per hour is specified: Wind pressure (pounds/square foot) = 0.0032 × (velocity in mph)^2. Redwood cooling towers are generally designed for a wind pressure of 30 lb per square foot on all cased and louvered walls. Earthquake loading factors (where applicable) should be in accordance with purchaser's specifications or governing building codes.

The calculation of stresses should be on the basis of actual net (finished) sizes of lumber used in cooling tower construction. Allowable unit working stresses established for permanent loading may be increased for a combination of permanent and short-time loading as follows:

(a) Combination of permanent and wind or earthquake loading.

(b) Combination of permanent and ice or snow load.

The dry weight of redwood lumber is about 3 lb per board-foot, the wet weight about 4 lb per board-foot.

Mechanical Equipment

Cooling tower fans and fan-drive assemblies should be selected to obtain maximum air flow with a minimum of horsepower. The fan-drive assembly shown in Fig. 2 is a typical arrangement. The motor is generally placed outside the fan cylinder so as to avoid contact with the moist, humid exit air of the tower; this location necessitates the use of a floating drive shaft. The motor usually operates at 1800 rpm and the fan about 300 rpm (or less), hence a gear reduction unit is required to give the fan its desired speed. Flexible couplings join the motor, drive shaft, and fan to form a compact fan-drive assembly.

Fan Cylinder. The fan cylinder is an important factor in determining the over-all efficiency of a fan drive. The cylinder should be close enough to the tip of the fan blade to minimize air recirculation, yet far enough away to be mechanically safe. The fan cylinder shown in Fig. 2 is typical modern design. It is made of redwood and is built for long life with minimum maintenance. Redwood requires no painting. The cylinder should be built high enough for safety and low enough for easy inspection. The bottom of the cylinder should be flared out so that in effect the fan is operating in the throat of a venturi.

Fans. Cooling tower fans seldom exceed 24 ft in diameter. Most of these fans are placed atop the towers, hence they should be carefully balanced and correctly pitched to prevent harmful vibrations. Fans should not have too high a sound level; therefore, the tip speed and rpm should be kept at relatively low values.

Cooling tower fans move large volumes of air at relatively low static pressures; therefore, they should be specifically designed to give top aerodynamic performance under these conditions. The fans should be able to operate continuously in hot, humid atmospheres without undue deterioration. Several construction methods may be used on cooling tower fan blades; they might be made as a solid casting (Fig. 2), a "skin" over a framework, or a skin alone. Some of the materials used in blades are cast aluminum, stainless steel, formed steel, plastics, and laminated wood.

The fan blade pitch should be adjustable so that the desired volume of air can be moved, yet no more power used than necessary.

Fan Performance. The air requirements of a cooling tower are primarily dependent upon the cooling desired and the tower design. Fans for cooling towers, Fig. 2, must move large volumes of air at a low velocity (maximum about 2000 fpm at exit) and with a small pressure drop (less than 0.5 in. water) through the tower. This unique fan application requires special design considerations to insure efficient operation for a desired cooling tower performance.

Basically, each cooling tower fan should be selected to provide the desired volume of air with a minimum power input. For a given cooling duty, towers of different manufacture may require fans with varying physical dimensions and operating characteristics. The fan must be selected to fit the cooling requirements of each application, because towers differ in their design and performance, which in turn affect the relation between the volume of air and the pressure drop. It should be emphasized that tower fan selection should be based upon the overall fan and cylinder application, i.e. upon data obtained from tests made with the fan installed in the fan cylinder in which it is to operate.

TABLE 1. Basic stresses* for clear redwood lumber.

Kind of Stress	*Basic Stress* lb per sq in.*
Extreme fiber, bending or tension parallel to grain	1750
Compression, perpendicular to grain	185
Compression, parallel to grain	1350
Horizontal shear in beams	100
Modulus of elasticity	1,200,000

*These stresses are based upon the strength of green lumber and are applicable with certain adjustments to lumber of any degree of seasoning.

Gear-Type Speed Reduction Unit. The speed reduction unit (Fig. 3) is used to support the fan, to transmit power to the fan, and to reduce driving electric motor speed to that suitable for a specific fan. The amount of reduction varies with diameter of the fan, even though more than one speed might be used for a given diameter.

Reduction unit should be designed specifically for cooling tower duty, as it is situated in a hot and humid air stream. The case must be sealed to prevent water leakage, and it should be able to breathe with temperature changes. Water condensing inside the case should not break down the lubricating oil and should be easily drained off. The lubricating system should give trouble-free operation no matter in which direction the fan is operating.

Drive Shaft. The drive shaft (Fig. 2) is used to transmit power from the fan motor outside the air stream to the speed reduction unit. It should be dynamically balanced to prevent its causing undue wear in the bearings of electric motor and reduction unit. The drive shaft should require little or no maintenance because operators tend to neglect it. As a safety precaution, the drive shaft should be looped by steel straps so that if a coupling should break because of excessive vibration, the released shaft would cause little or no damage. The couplings of the drive shaft should be so made that they can be easily replaced while the shaft is in position on the tower.

Electric Motor. Cooling tower motors should, in the opinion of the motor manufacturer, be suitable for this type of application. They should be able to operate continuously in a humid atmosphere or to be shut down for several months at a time without damage. Joints of motors should be tight enough to prevent water leakage. If motor manufacturer thinks water may get into the motor, some means of draining that water should be provided. Two-speed motors are recommended where a cooling tower will be operated in cold weather, as they offer better control of the air. In very humid climates or in places where acid or alkali fumes are present, it is advisable to use totally enclosed motors. In other installations splash-proof motors have proved satisfactory.

Belt Drive. A V-belt drive is an economical, relatively noiseless, method of transmitting power. This is the most

PROCESS EQUIPMENT NEWS

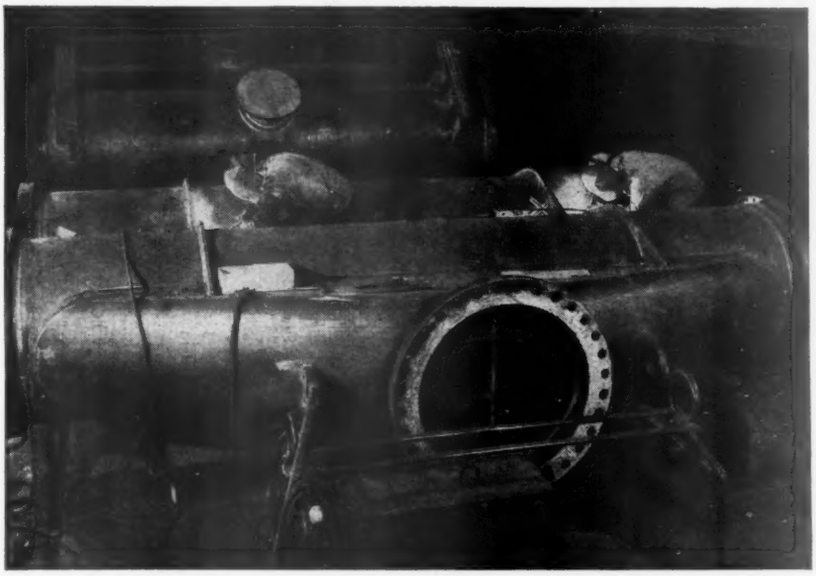
PUBLISHED BY FABRICATED PRODUCTS DIVISION, THE M. W. KELLOGG COMPANY APRIL-MAY 1954

3,360 Red Brass Tubes for This Condenser

Shown on one of Kellogg's boring mills (below) where the gasket face is being machined, this is a channel for one of four sections of a prefractionator condenser currently underway for a southwestern petroleum refinery.

Each bundle of the condenser will contain 840 tubes, ¾ inch in outside diameter by 16 feet in length. The water available for industrial purposes in the particular area where the condenser will be used is especially corrosive. To offset this, specifications call for red brass as the material for the tubes, this alloy having proved by experience to give the most effective protection against corrosion in the locality involved.

Tube sheets for the condenser will be of steel, clad with naval brass. Shell, shell cover, and channel are of steel. Design temperature is 200°F. on the shell side and 150°F. on the tube side.



Big Condenser Will Hold Pressure Drop to 5mm. Maximum

The drip-type condenser shown above in progress in Kellogg's shop has been designed to hold pressure drop on the shell side to the exceptionally low maximum of 5 mm. of mercury. Consisting of two sections, the unit will condense naphtha vapors and steam on the shell side and heat a petroleum distillate on the tube side. Operating pressure on the shell side will be 65 mm., and 150 psi. on the tube side.

Representative of one of the more complex types of exchanger units Kellogg is experienced in building, in addition to all the conventional types, this condenser is designed with an obround nozzle to spread the incoming vapors over the entire length of the tube bundle, thus providing for pure cross-flow heat transfer.

44,000-lb. Reactor for New Chemical Process

Similar in design to units refiners use in transforming certain petroleum gases into polymer gasoline, this big reactor (right) will shortly become an important part of a new chemical plant now building on the East Coast. The plant will be the first in this country to manufacture phenol from cumene, an intermediate material which in turn is obtained from benzene and propylene. This particular unit is the vessel in which the reaction to produce cumene will be carried out.

The tubular reactor is 3½ feet in internal diameter by 35½ feet in length, and is fabricated of high-tensile carbon steel, 1⅝ inches thick. When completed, it will tip the scales at some 44,000 pounds. The unit is designed for an internal pressure of 990 psi, and temperature of 510°F.

For further information, details of methods, etc. contact
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popular drive used on small diameter fans. It may also be used on some intermediate diameter fans (less than 10 ft). Maintenance and repairs on the V-belt are simple and there should be no lubrication problems.

Sound Considerations

Predominant sources of sound emanating from a cooling tower are the water (close to the tower) and the fan with its drive (away from the tower). Fan and water sounds are of approximately equal loudness. Shutting off one but not the other will not appreciably reduce the total loudness level.

Location of Cooling Tower. Sound intensity level varies inversely as the square of the distance from the source in an unobstructed space. A reflecting surface near the source of the sound will intensify it in a given direction. Reflecting surfaces near the point of observation will collect and intensify sound at that point. When locating a tower, take advantage of any reflecting surfaces by using them to direct sound away from places not desired.

Fan Sound. Fan sounds can be subdivided into rotational and vortex sounds. Rotational sound is caused by rotation of the steady pressure field surrounding each blade, and its frequency is equal to the number of blades times the revolutions per second of the fan. At 10,000 fpm tip speed this sound is a moderate throb, and with the low rpm of the fan the throb has a noticeable pulse. The fewer the blades the more noticeable the pulse. Vortex sound is caused by the oscillatory acceleration of the air and is the predominant sound in low speed multiblade fans. The chief factor affecting loudness level for any given type fan is probably the fan horsepower, with speed another important factor. All other factors being equal (disc loading, tip speed), fan sound seems to be least at maximum efficiency.

Mechanical Drive Sound. Unbalance or misalignment in fan drive can be a major contributor to cooling tower sound. The fan drive can also be responsible for steel casing sheets vibrating. Fan and drive must be correctly balanced and in correct alignment to minimize loudness level. It might be advantageous to isolate the mechanical equipment from the tower structure with vibration absorbers.

Water Sound. Water sound in a cooling tower is affected by vertical distance between splash bars, water concentration and total vertical fall.

Ways of Reducing Sound. Muffling systems are available to reduce fan and water sound; these systems being applied to the air intake and discharge as required. When loudness level in a definite direction is to be reduced a deflecting baffle can be built; these baffles would reduce sound in one direction at the expense of increasing it in another. In some cases a sound is heard because the object creating it is seen, therefore blocking the view might stop some sound complaints. Sometimes feeling a vibration will draw attention to a small sound.

Pump Selection

All recirculating water-cooling systems require a pump to circulate the water. The pump and piping system are usually selected by the consulting engineer or purchaser of a cooling tower.

The material included here is basic information on pump selection and is the data desired when sizing a pump for cooling tower application.

Specific Pump Speed. Centrifugal, mixed-flow, and propeller pumps are generally used for circulating water. The impellers of these pumps are classified according to their performance and proportions. The term used for this classification is "specific speed," which is the speed in revolutions per minute at which an impeller would operate if reduced proportionately in size so as to deliver a rated capacity of one gallon per minute against one foot of total head. The required specific speed of a pump for a particular job can be determined by the following equation:

$$N_s = \frac{\text{rpm } (\text{gpm})^{0.5}}{H^{0.75}}$$

Where H = head pumped against in feet, i.e., static lift, velocity, and friction loss are all considered.

Types of Pump Impellers. There is no set dividing line in the specific speeds for the different impeller designs; however, the following ranges are acceptable and are fairly correct. For heads above 150 ft and specific speeds between 500 and 3000, radial-type centrifugal impellers are used. These impellers may be single or double suction design, depending upon the volume flow.

For lower heads (less than 150 ft) and specific speeds between 1500 and 4500, a Francis-type impeller is used. Mixed-flow impellers are used for specific speeds between 4500 and 8000, and propeller-type impellers for specific speeds above 8000. For heads too great for one stage, several impellers are mounted on one shaft in series. Usually radial impellers are used for this multi-staging since they develop greater heads than the other types.

EXAMPLE. Assuming an 1800 rpm pump is to circulate 7000 gpm at a 50 ft head, the specific speed would be

$$N_s = \frac{1800 \times (7000)^{0.5}}{50^{0.75}} = \frac{1800 \times 83.6}{18.8}$$

$$N_s = 8000$$

From the results obtained this pump would probably be a mixed-flow pump, but it could also be a propeller type at this specific speed.

Efficiency of Rotating Pumps. The overall efficiency of rotating pumps may be considered as equal to the product of (1) mechanical efficiency, (2) hydraulic efficiency, and (3) volumetric efficiency. The mechanical efficiency considers friction losses in bearings and packing boxes. Hydraulic efficiency considers the water friction and turbulence losses. Volumetric efficiency considers water leakage (around the impeller).

Pump Cost vs. Speed. When buying a pump, the highest speed pump would probably have the lowest first cost, the same maintenance, and smaller size with same horsepower as a lower speed pump. The over-all cost of the highest speed pump would probably be the least.

Data Required When Ordering Pumps. The following information should be supplied the pump manufacturer when ordering a pump:

(1) Maximum and operating gpm. It is best to oversize pump to take care of extra gallonage or system friction loss.

(2) Temperature of the flowing water.

(3) Available suction head, see discussion above. The circulating system might have to be revamped to change this value if the pump manufacturer deems it necessary.

(4) Total head of the system. This includes velocity head, static lift, and friction loss of the entire system.

(5) Type pump, see discussion on impellers above.

(6) Type of connection for suction and discharge pipe (screwed, flanged).

(7) Kind of service (continuous or intermittent).

(8) Type driver, horsepower, speed, rotation, shaft size, and who will provide. If possible, it is better not to specify speed. Allow for about 75 per cent pump efficiency.

Tower Placement

For most effective summer operation, a tower site should be selected that allows unrestricted air flow to the unit and a minimum of interference from outside influences. As much open space as possible should be allowed between the cooling tower louvers and nearby structures (this is especially true for large capacity towers). When the louvered face of a tower must be placed near a solid wall, it is advisable to raise the supporting structure of the tower by means of steel posts or concrete

piers to allow ready air access. This increased height should be sufficient to allow for a combined inlet air area between wall and tower, at sides and bottom, that will equal or exceed the net louvered area of the tower on the restricted side.

Recirculation of Air. When there is no wind movement, the hot discharge air-vapor from a cooling tower moves vertically into the surrounding air. When the wind is blowing, it will carry the air-vapor discharge from a tower downward toward ground level because of the lower pressure on the leeward side of the tower; the higher the wind velocity the more pronounced will be this action. Recirculation will occur when some of the air-vapor discharge of a tower re-enters the air-intake louvers of this tower or a nearby tower.

A site selected for a cooling tower installation which would place the tower near an adjacent structure would create the dual possibility of recirculation and restricted inlet-air flow. Recirculation of air may take place with certain wind conditions on a multiple-cell tower even when it is placed in an open area with no nearby obstructions. The amount of recirculation is a function of the length of the tower, the wind direction, the velocity of the wind, or a combination of these three factors.

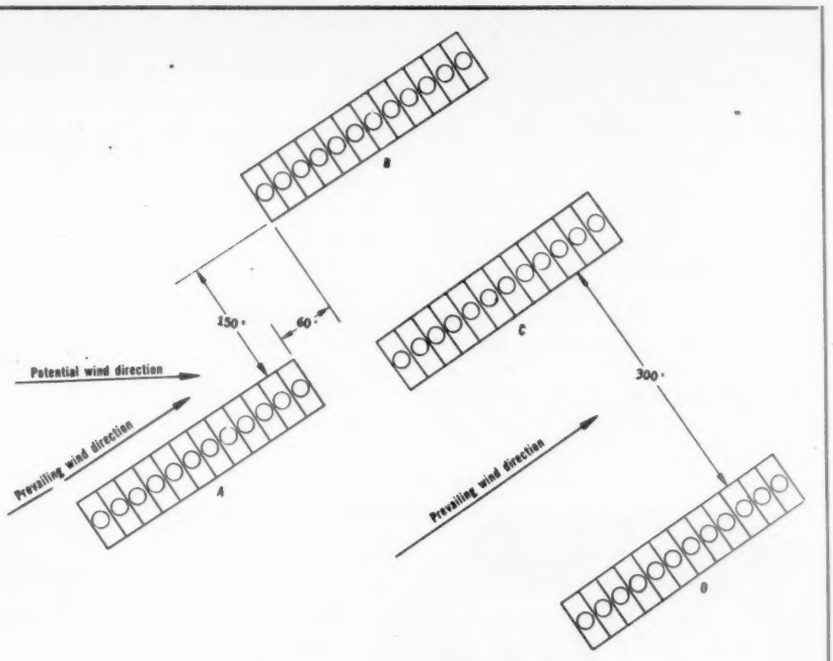

FIG. 4. Arrangement of towers with respect to prevailing wind direction, set to minimize recirculation of air.

For tower A, Fig. 4, the prevailing wind moving parallel to the longitudinal axis of the tower would carry the air-vapor discharge along so that the initial cells (lower right) would not be affected. As the number of cells increases, and when there is a wind blowing, the exit air-vapor of a tower would

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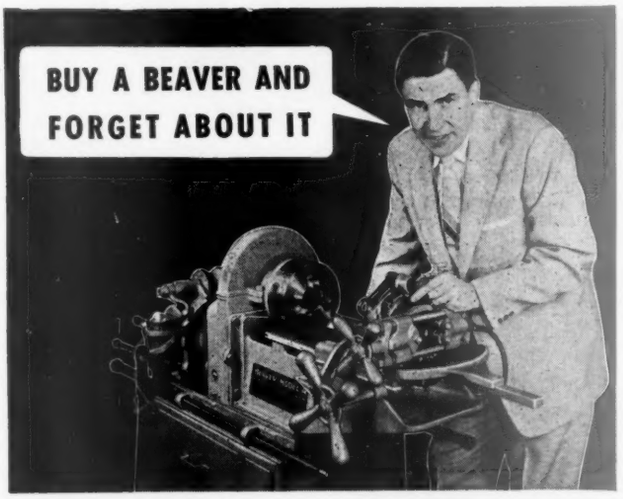

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be carried down toward its louvered sides and reduce the entrance of fresh air, especially at the leeward end cells of the tower. With an increase of wind velocity the blanketing effect of the recirculated air would begin at a point nearer to the windward end cell, and as a result the recirculation on the total tower would increase proportionately. Because of this recirculation possibility, it may be advisable to use two (or more) towers when six or more cells are required for large water-cooling requirements.

Multiple Towers. If an additional tower were required, the second unit (B or C, Fig. 4) should be offset to the potential leeward side and sufficient distance allowed between towers so that the second tower will not be subjected to vapors of the first. The offset distance and the longitudinal distance between the two towers would depend upon the average prevailing wind velocity.

If two sections were placed end to end, with a space in between without the offset, the center opening might actually increase the recirculation on the second half by pulling the vapors down from the end of the first tower and so more effectively blanket the initial cells of the second tower. This arrangement would undoubtedly help in the case of a broadside wind because it would allow a portion of the fresh air to pass between the two adjacent ends and then be drawn either way to the leeward sides of both towers. Towers should be placed at right angles to a prevailing broadside wind, however, only as a last resort.

In the event that the length of the plot of ground available does not permit placing the towers parallel to the prevailing wind and with the second half offset to the potential windward side, it may be necessary to place the two sections opposite and parallel to each other (C and D in Fig. 4). If this plan were followed, both towers should be placed in line with the prevailing wind and enough lateral space allowed between towers so that one will not be affected by the vapors from the other. With this plan of arrangement a broadside wind would bring fresh air to only one side of one tower and therefore the resulting recirculation on both towers could approach 75 per cent.

It must, of course, be recognized that the velocity and wind direction do not remain constant and that regardless of the selected tower placement there will be times when the tower is operating under adverse conditions. Generally speaking, crossflow towers have not indicated any substantial loss in performance due to recirculation. The crossflow tower, due to its structural design has certain features that tend to decrease the tendency for recirculation as compared to the counterflow tower.

Louvers of the counterflow tower are farther away from the discharge vapors of the fan, which gives greater chance for the higher wet-bulb air to diffuse with the atmosphere. The air intake rate (feet per minute) through the louvers of the cross-flow tower is lower than that of the counterflow tower and, consequently, the low pressure area is not as great at the external face of the louvers. When the wind blows toward the louvers of a crossflow tower, more fresh air (less recirculated air) enters, as compared to an equivalent counterflow unit which would have a higher entering air velocity; consequently, the recirculation on the total tower would be less with the crossflow design than with counterflow towers. *

Part 4 on "Testing the Performance of Industrial Cooling Towers" will appear in an early issue of *The Petroleum Engineer.*

Shell Luboil Unit. The luboil unit recently installed in Shell Oil Company's refinery at Curacao, West Indies, has a capacity of 3500 bbl a day. This was given as 2100 bbl a day in last month's issue, Page A-49.

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Changed Consumer Demand Requires New Techniques, Products

Refining processes undergoing revamping and revision to keep up with need for new properties from old products

ARCH L. FOSTER*

NEW developments, new demands for different products and different properties for old products are speeding the revision and ultramodernization of refining processes, as shown by speakers before the 1954 annual meeting of the Western Petroleum Refiners Association at San Antonio, Texas, March 29-31. The postwar average of petroleum product demand increase of about 6 per cent over each preceding year may continue in 1954, Roland V. Rodman, WPRA president, told his colleagues, even though business in general may slow down a little from it postwar rate of climb.

The number of cars and trucks on the road probably will increase in 1954, Rodman said. While rising oil production, aided by foreign crude imports, outstripped demand in the latter part of 1953, stocks are 11 per cent higher than for the previous second-half of 1952. Greater price advantage for gasoline over other heavier products pushed gasoline output upward, so that by mid-'53 45.6 per cent of each crude barrel went into motor fuels, more than 3 per cent higher yield than in 1952. Diesel and burning oils dropped from 38.8 per cent to 36.9 per cent of the barrel. Domestic consumption this year will be three times that of 1929, when most of the use, and the increase, came from highway use, generally about two-thirds of the market. Home and commercial demands account for much of the rise in the last 25 years, from 4 per cent in 1929 to 15 per cent in 1952. Even if new car-truck production falls below 1953, the number on the roads will increase 3 to 5 per cent, insuring increased petroleum consumption.

Railroad diesel fuel rose from about 2,000,000 bbl in the late 1920's to 68,000,000 in 1952; diesel locomotives increased from about 4000 in 1945 to 21,000 in 1953. Residual fuel oil consumption dropped from 116,000,000 bbl in 1945 to 40,000,000 in 1952, Rodman pointed out.

Outstanding among the controlling conditions of which the country in general may lose sight, is the fact that, as Rodman puts it, "To make any product from a barrel of crude it is necessary to make products from the same barrel of crude oil." Prices and price ranges must be so established that the manufacturer of various products will be dictated both by product demand and by industry economics. The "indefensible" race for octane carried on since the war's end raises a situation that calls for "A complete restudy of differentials between regular and premium gasolines." In other words, engines calling for ultrafuel should pay for it; the price differential between regular and premium gasoline should be greater than is the average at present. Present excesses refining capacity, dictated by national defense needs, must be handled realistically or "instruments in our hands, created for national defense, will have brought about our own destruction."

"Demagogs are yelling that the coming of peace and an honest dollar are driving us into a depression" the speaker said in conclusion. "If their theory is correct, then war and inflation are necessary to American prosperity. That would mean that continued prosperity was dependent on the spilling of the blood of our youth on the battlefield and the dissipation of the purchasing power of the dollar."

Cat Reforming, Coking Important Processes

Much attention was given at the meeting to new developments in processing, especially catalytic reforming, treating, and coking heavy residuals. The UOP-Union Oil Unifining process takes advantage of cheap hydrogen to remove sulfur, nitrogen, and oxygen from distillates, using cobalt-molybdenum catalyst, operating in conjunction with catalytic reforming units to use the excess hydrogen so produced. The reaction is that of breaking the hydrocarbon chain where the impurity, sulfur, etc., is attached, and forming hydrogen sulfide, ammonia, or water therefrom. This raises the octane rating somewhat, improves more the lead susceptibility with little if any volume loss. Cetane number in diesel fuels has been raised by as much as 6 numbers by unifining the fraction. Estimates show that the installation cost of these units ranges from $75 to $175 per barrel of daily capacity.

Catalytic reforming of distillates under conditions that take advantage of the use of lower pressures shows distinct improvements in this operation, say Standard of Indiana technologists, of the Ultraforming process developed by that company. (Details of this process are given on page C-35, April 1954 issue of Petroleum Engineer). The platinum-containing catalyst is regenerated in place, periodically. At lower pressures, 200 psig compared to 500, the yield of pentanes-and-heavier product is raised 9 per cent in one instance. Aromatics are produced "in good yield." The catalyst contains 0.6 per cent of platinum, and regeneration restores it completely to fresh condition.

Olefins by Pebble Heating

Phillips' new pebble heater design gives greatly increased yields of olefins and acetylene from cracking ethane-to-butane at elevated temperatures, the meet was told. Fifty per cent greater yield of ethylene are obtained from cracking normal butane than is found by tube furnace cracking. The system includes a mass of refractory spheres or pebbles that are circulated from a container into a preheater, thence into the cracking zone or reactor, and return by air lift to the storage container again.

A typical operation shows a yield of 44.1 lb of ethylene, and 12.5 lb propylene per 100 lb of butane feed. The Borger, Texas, pebble heater will produce 74,000 lb ethylene and 21,000 lb propylene daily, it was reported. Temperatures employed are of the order of 1600 F or higher in the reactor.

Coking Processes Improved

Coking of heavy residuals by the fluid process will show a value differential between charge and products of $1.25 to $2 per barrel, says Standard Oil Development technologists. Coking occurs at 900-1050 F, and the coke is withdrawn in the form of small pebbles or granules, thus permitting the process to be continuous without multiple chambers. "Seed coke" is returned to the system to produce larger pieces. On vacuum residue yields shown are 8 to 10 per cent C_3 and lighter; 22-24 per cent naphthas, and 45-61 per cent gas oil and 16-34 per cent coke. On a long residuum C_3-and-lighter yield was esti-

*Editor, Refining, Petrochemical, Gas Processing.

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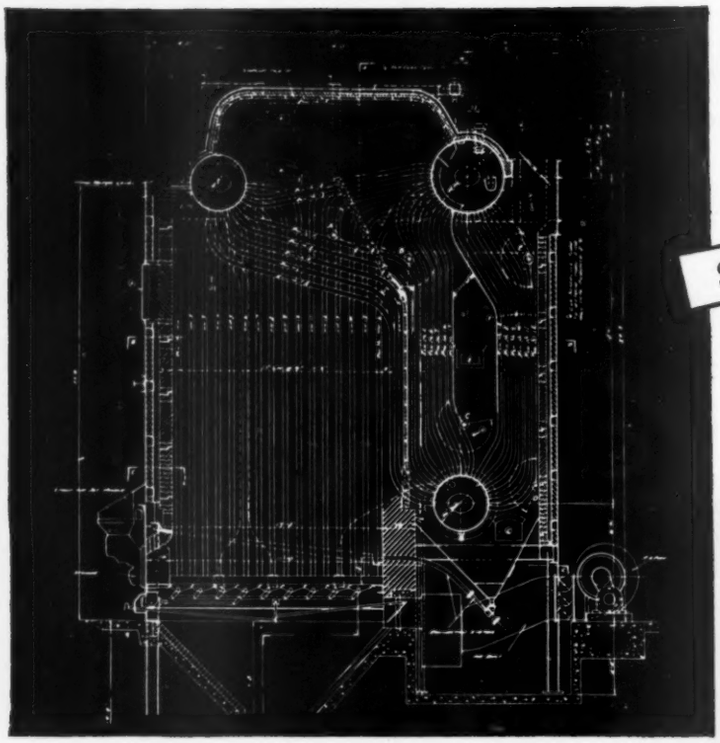

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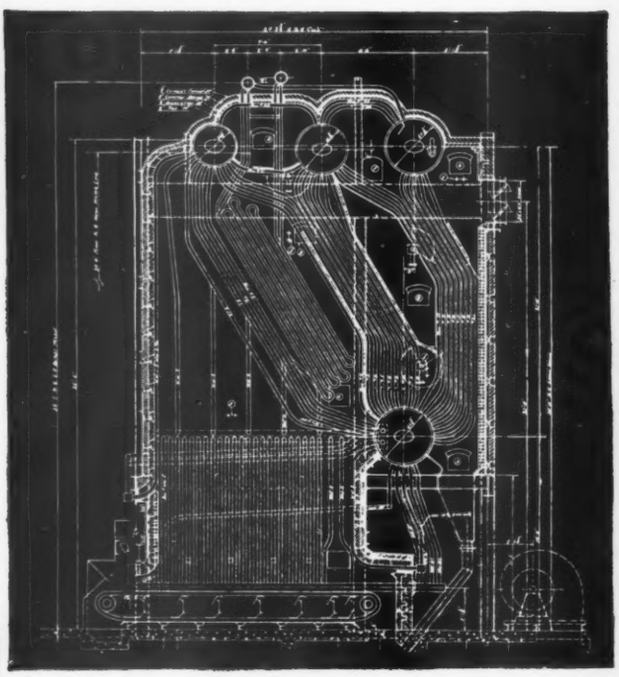

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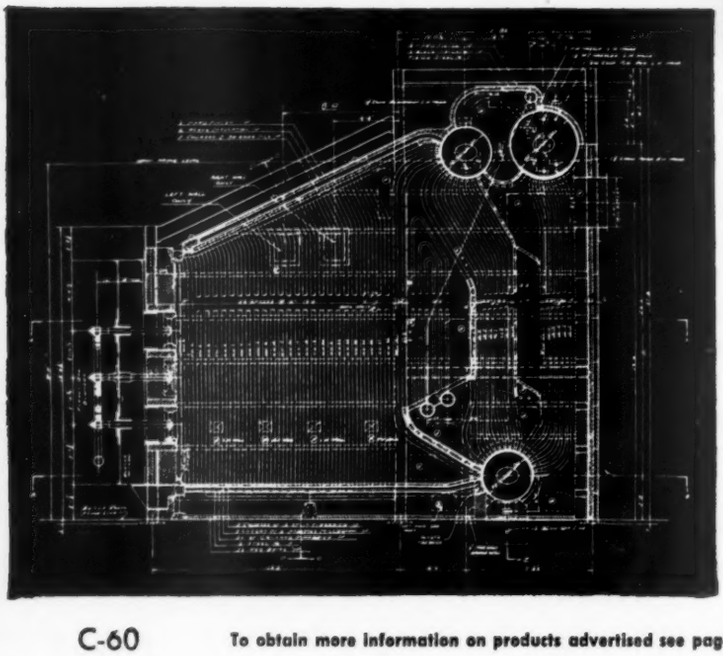
CLASS LE Mt. Carmel Public Utility, Mt. Carmel, Illinois, is served by this 60,000 pounds per hour unit. Generous steam liberating surfaces and steam space permit wide fluctuations in load.

CLASS VR 70,000 pounds per hour steam generator at Humble Oil and Refining Company, Johnsue, Texas. An efficient, high-duty unit with water cooled furnace, using refinery gas fuel.



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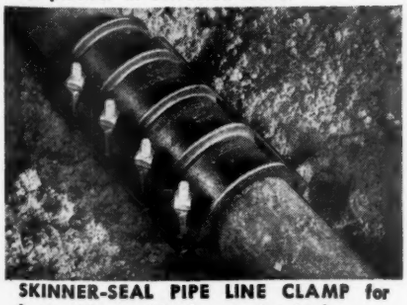

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mated at 6 per cent; C_4, 2 per cent, naphtha, 14 per cent, gas oil 72 per cent and coke, 13 per cent.

Coking of heavy residues via the older coke-oven process, has been employed in several locations for many years, especially for making metallurgical coke, M. D. Curran of Curran Carbonizing and Engineering Company said. The heavy oils are coked on a hearth or oven floor, the overhead vaporized products are collected generally in two streams, naphtha and gas fractions. Typical yields from a 225 F melting point pitch are: Distillate oils, 45 per cent; wet gas, 18-20 per cent; coke, 35-37 per cent. February 1954 published prices for coke per ton range from $24-$26 f.o.b. ovens, Curran stated.

Much higher percentage removal of mercaptan sulfur can be obtained by the use of the new Dualayer process, developed by technologists of Magnolia Petroleum Company, than can be obtained from other processes in use by the industry. Figures reported before the meeting show that a one-stage Dualayer treatment removes 91 per cent of the marcaptan sulfur from a West Texas gasoline, with solution-gasoline ratio of 0.02. Two or more stages remove the sulfur quantitative. This process is discussed in detail in our April 1954 issue of Refining and Petrochemical Edition, page C-106. * * *

Refinery Shut Down. Shell Oil Company's refinery on Aruba, Netherlands, West Indies, has been shut down since January 1953.

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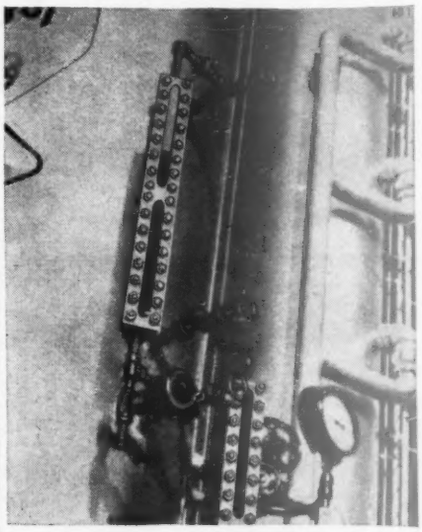

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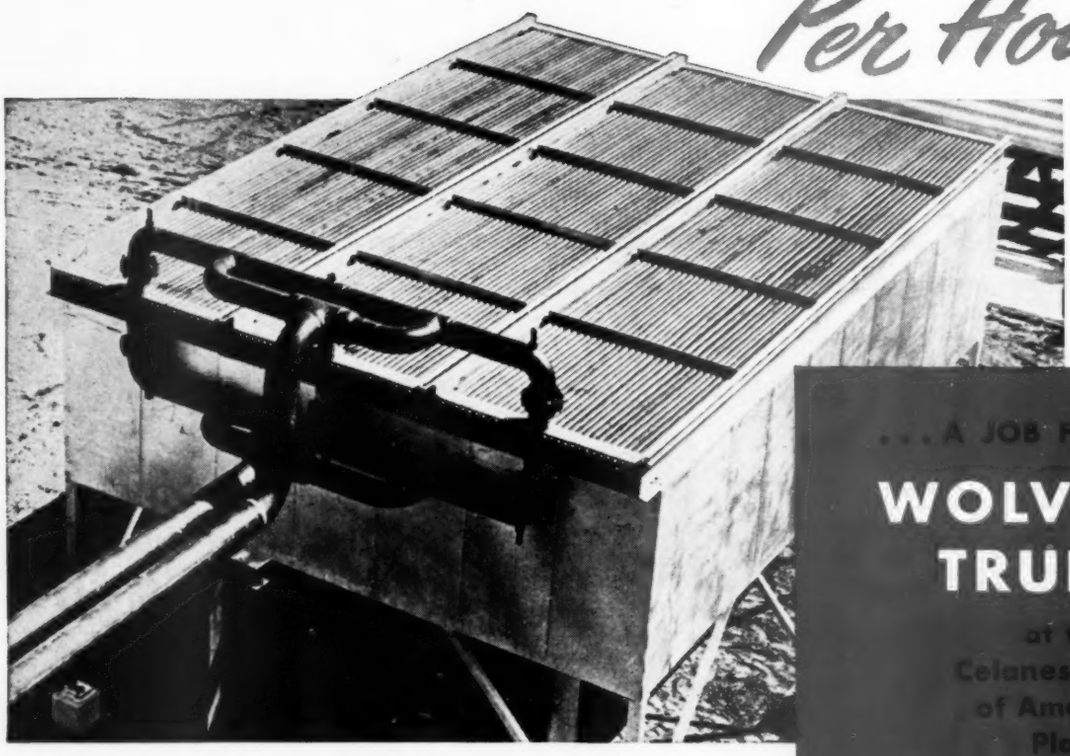

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IMPURITIES IN AND TEL SUSCEPTIBILITY OF SHALE OIL MOTOR FUELS

"TEL efficiency" in shale gasolines averages 24 per cent

GEORGE E. MAPSTONE

DURING the last few years petroleum circles have developed an increasing interest in the production of shale oil as a potential substitute or replacement for flow oil. At present there is no commercial production of shale oil in the U. S. A. though much work has been carried out on the developmental side by the Bureau of Mines. On the other hand shale oil has been produced in Scotland since 1850 and also in Australia since 1939, as well as in several other countries whose natural supplies of petroleum are scanty.

Australian shale oil has been refined by thermal cracking in a Dubbs two-coil selective cracking plant with thermal reforming of the shale naphtha.

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TABLE 1. Analysis of Dubbs cracked shale gasoline. (Residue operation)

Cut no.	Orignal	1	2	3	4	5	6	7
From deg. F	—	—	104	157	212	257	304	347
To deg. F	—	104	157	212	257	304	347	420
Volume per cent[1]	100	12.2	22.8	25.2	21.0	10.0	4.0	1.8
Specific gravity at 60 deg. F	0.726	0.652	0.692	0.728	0.740	0.764	0.782	0.810
Distillation deg. F 10%	162	78	148	194	230	272	320	342
50%	206	91	150	201	239	283	330	370
90%	283	103	156	215	254	295	343	409
Mean molecular weight[2]	99	70	85	97	108	121	135	147
Hydrocarbon analysis								
Olefines[3]	56.5	65	58	58.5	54.5	63	52.5	77
Aromatics[4]	7	0	2	5	7	−1.5	7.5	−7.5
Napthenes[5]	7	0	8	7.5	6	4	4.5	0
Paraffins[6]	29.5	35	32	29	32.5	34.5	35.5	30.5
Tar acids % by volume[7]	0.00	0.00	0.00	0.00	0.00	0.00	0.6	0.7
Total sulfur % by weight[8]	0.29	0.14	0.12	0.20	0.29	0.36	0.42	i.s.
Mercaptan sulfur % by weight[9]	0.051	0.145	0.023	0.004	0.002	0.005	0.009	0.059
Basic nitrogen % by weight[10]	0.002	0.000	0.000	0.002	0.003	0.001	0.003	0.005

[1] Volumes of fractions corrected for handling losses.
[2] From distillation range and API gravity (3).
[3] From bromine number (4).
[4] From absorption in Kattwinkel's reagent corrected for olefine content (5). Negative values may be due to the presence o diolefines and/or loss of aromatics by alkylation in which case they would be classified as olefine polymers.
[5] From aniline point of distilled residue from Kattwinkel extraction (5).
[6] Loss in volume on washing with 20% caustic soda (6).
[7] Lamp method.
[8] Modified Borgstrom and Reid method (7).
[9] By acid extraction and back titration (8).
i.s. insufficient sample.

TABLE 2. Analysis of Dubbs cracked shale gasoline. (Coke operation)

Cut no.	Orignal	1	2	3	4	5	6	7
From deg. F	—	—	104	158	212	257	302	347
To deg. F	—	104	158	212	257	302	347	392
Volume per cent	100	17.8	15.4	20.3	17.9	15.1	9.7	2.0
Specific gravity at 60 deg. F[1]	0.742	0.643	0.696	0.731	0.759	0.793	0.841	0.878
Distillation deg. F 10%	146	79	148	158	233	280	328	353
50%	224	91	152	197	241	289	332	364
90%	316	105	158	206	256	301	343	388
Mean mol. weight[2]	98	70	84	94	105	117	126	133
Total sulfur % by weight[7]	0.37	0.08	0.24	0.34	0.40	0.63	0.83	1.5
Mercaptan sulfur % by weight[8]	0.018	0.045	0.013	0.008	0.007	0.004	0.001	1.5
Tar acids % by volume[6]	0.42	0.0	0.0	0.0	0.0	0.0	1.19	2.85
Basic nitrogen % by weight[10]	0.089	0.000	0.000	0.003	0.003	0.097	0.342	0.380

[1] Volumes of fractions corrected for handling losses.
[2] From distillation range and API gravity (3).
[3] From bromine number (4).
[4] From absorption in Kattwinkel's reagent corrected for olefine content (5). Negative values may be due to the presence of diolefines and/or loss of aromatics by alkylation in which case they would be classified as olefine polymers.
[5] From aniline point of distilled residue from Kattwinkel extraction (5).
[6] Loss in volume on washing with 20% caustic soda (6).
[7] Lamp method.
[8] Modified Borgstrom and Reid method (7).
[10] By acid extraction and back titration (8).

The cracked product was refined by acid treatment followed by re-running and doctor sweetening.[1,2] Some of the properties and peculiarities of this shale gasoline are presented in this article.

Analysis of the Gasoline

In addition to the usual range of hydrocarbons and sulfur compounds normally present in gasoline, shale gasoline also contained small amounts of basic nitrogen compounds (pyridine homologues), pyrroles and phenols. Results of the examination of samples of the stabilized pressure distillate from residue and coking operation are given in Tables 1 and 2. A similar examination of the shale naphtha has

The Author

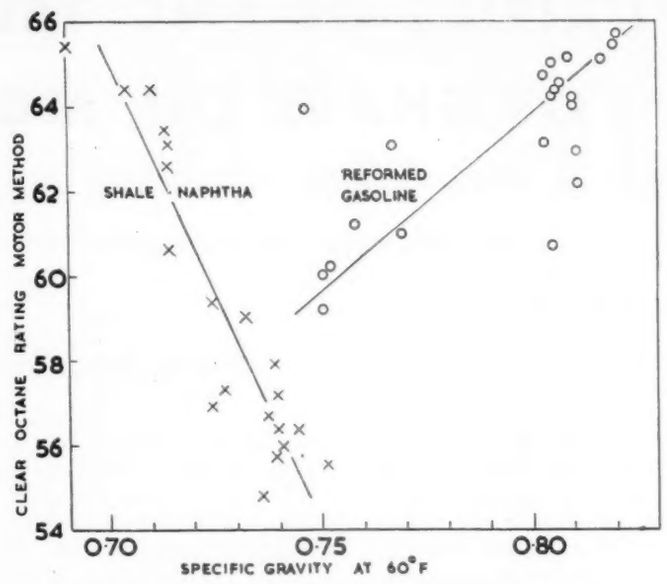
George E. Mapstone is research and development chemist in charge of research and development for the South African Torbanite Mining and Refining Company, at Boksburg, North Transvaal. A graduate of the University of New Zealand, where he was born, Mapstone entered oil shale work with National Oil Pety. Ltd., at Glen Davis, New South Wales, Australia, in 1941 upon his graduation. In turn he was laboratory chemist, technical assistant to the carbonizing superintendent, assistant chief chemist, then chief chemist from 1946 to 1951.

This work gave him invaluable research experience, in developing ways and means for refining the crude shale oil as well as in control matters. When the Australian Government closed the shale oil work as an economy act, he joined the Commonwealth Scientific and Industrial Research Organization (more or less comparable to our U. S. Bureau of Mines) as principal research officer in the coal research section, where he remained until assuming his present position.

been published previously.[9] The results of several typical PONA analyses are given in Table 3.

The only individual constituents of the gasoline that have been identified are cyclopentadiene (using Afanas'ev's test)[10] and carbon disulfide.[9] The latter was present in the stabilized pressure distillate in amounts up to 0.3 per cent by weight of sulfur, but the finished gasoline normally contained only 0.02 to 0.07 per cent by weight of carbon disulfide sulfur.

As the treatment processes do not effect its removal in any way the decrease from approximately 0.16 per cent of carbon disulfide sulfur to an average of 0.04 per cent was due entirely to evaporation and breathing losses in the intermediate storage tanks during processing. This means that, if these normal breathing losses are prevented by improved storage facilities, the removal of this troublesome constituent would be necessary in order to reduce its effect on lead susceptibility, etc., of the finished gasoline.[11] Preliminary laboratory work has indicated the feasibility of removal of the carbon disulfide by washing with caustic soda solution containing various additives at slightly elevated temperatures.[12]



Specific gravity octane rating relationships for shale naphtha before and after reforming.

Octane Ratings.

The stabilized pressure distillate from the Dubbs cracking of Glen Davis crude shale oil normally had a motor octane rating of 63 ± ½, though it ranged between 61 and 65 on normal operation, a factor that appears to be attributable to the inherent variability of shale oil.[13] The research rating was normally six to eight numbers higher than the motor method rating.

The lead susceptibility of a sample of the treated gasoline (Table 4) is given in Table 5 together with some estimates of the TEL efficiency. From the data recorded in Table 5 it would appear that the sulfur compounds present in the treated gasoline have an average effect on the TEL efficiency equivalent to that of an equal amount of organic sulfides.

A significant relationship was found between the clear octane rating (MM) and the specific gravity of the re-run gasoline. The correlation coefficient was minus 0.570 indicating that, with these samples, some 32 per cent of the factors influencing the octane rating also influence the specific gravity. Because of the spread of the results it was not possible to obtain sufficiently accurate estimates of the octane rating from the specific gravity for plant control or for checking the operation of the CFR engine.

The shale naphtha showed the same type of specific gravity-octane rating relationship as the gasoline, but the reformed gasoline showed the reverse relationship (Fig. 1), the rating increasing with specific gravity. This is in agreement with the high aromatic content of the reformed gasoline (Table 3), and supports the contention that the octane improvement on reforming is due to aromatization of the product.

The raw pressure distillate contained approximately 0.25 per cent of tar acids, principally cresols with some phenol and xylenols. Most of these were recovered from the various caustic washes but sufficient remained in the finished gasoline to give an induction period in excess of 1000 min. At one stage the possibility of returning the recovered and purified tar acids to the gasoline was investigated and their blending octane rating was determined (Table 6). This was significantly higher than that of the tar bases, which are present to the extent of approximately 0.3 per cent and which have a blending octane rating of a little more than 100.[15]

Acid Treatment

Examination of the acid treatment process showed that the major reduction in the sulfur content was due to alkylation of thiophenes by the olefins, and the removal of the high-boiling alkyl thiophenes with the re-run bottoms.[16] The extent of this effect can be gaged from the total sulfur contents

TABLE 3. Pona analyses of some samples.[a]

Sample	Pressure distillate				Reformed gasoline	Shale Naphtha	
Operation type	Resid	Resid	Coke	Coke			
Paraffin	36	30	32	37	19	29	31
Olefins	46	60	57	50	44	49	51
Naphthenes	7	9	10	7	7	9	6
Aromatics	8	1	1	6	30	13	12

(a) The variations shown for samples from the same type of operation are typical of the results obtained and are probably due to the inherent variability of shale oil [13].

TABLE 4. Examination of shale gasoline sample used for TEL efficiency (Table 5).

S.G. at 60° F	0.736	
Distillation	I.B.P.	100 F
	10%	140 F
	50%	237 F
	90%	331 F
	F.B.P.	397 F
R.V.P.		5.6 lb
Total sulfur		0.21% by wt

TABLE 5. TEL susceptibility and efficiency in shale gasoline.

TEL cc/gal.	O.N.[1]	O.N. incr.	TEL[2] effic.	Calc. O.N.[3] incr.	Exptl. diff.	O.N. for 100%[4] TEL effic.
nil	62.3	0		0	0	62.3
0.76	67.5	5.2	24.6%	5.1	+0.1	77.0
1.52	70.9	8.6	22.5%	9.1	−0.5	82.9
2.28	73.4	11.1	22.0%	11.8	−0.7	86.1
3.04	76.2	13.9	22.8%	14.4	−0.5	88.5
3.80	79.2	16.9	25.3%	16.4	+0.5	90.5
4.56	81.1	18.8	27.0%	18.1	+0.7	92.0
			av. 24.0%		−0.07	

[1] MM octane rating, average of duplicate determinations.
[2] Calculated by the method of Livingstone (14) on the assumption that the lead susceptibility of gasoline, if it could be completely freed from sulfur compounds, would be the same as that of 60 O.N. primary reference fuel.
[3] Octane number increase assumed equal to that of 60 O.N. primary reference fuel containing 24.0% of the TEL content.
[4] Lead susceptibility assumed to be equal to that of 60 O.N. primary reference fuel.

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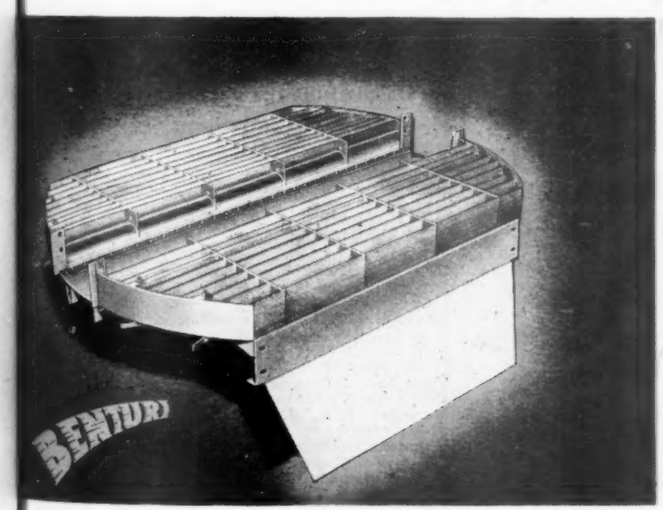

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of the various refinery streams given in Table 7. The variations recorded for different days are typical for the process and appear to be a characteristic of shale oil processing.[13] One factor brought out by the work was that treatment at sub-atmospheric temperatures as in the Stratcold process reduced the desulfurization efficiency roughly in proportion to the reduction in treatment loss.

Catalytic Treatment

Since it appeared that catalytic desulfurization to increase lead susceptibility, and possibly accompanied by some catalytic reforming gave the best prospects of meeting potential octane increases, the action of various catalysts on the gasoline was determined both in the laboratory and on a semi-pilot scale.

Anhydrous aluminum chloride was found to be the most reactive of the various desulfurization catalysts examined, ferric and zinc chlorides being appreciably less effective, in agreement with their weaker Friedel-Crafts' activity.

Anhydrous aluminum chloride has been used successfully for the removal of thiophene from benzene[17] and, in view of the high proportion of thiophene sulfur in the gasoline,[16] the reaction appears to be equally effective with thiophene homologues even when in dilute solution in a highly olefinic gasoline. Unfortunately some polymerization and hydrochlorination of the olefins took place at the same time with overall detrimental results.

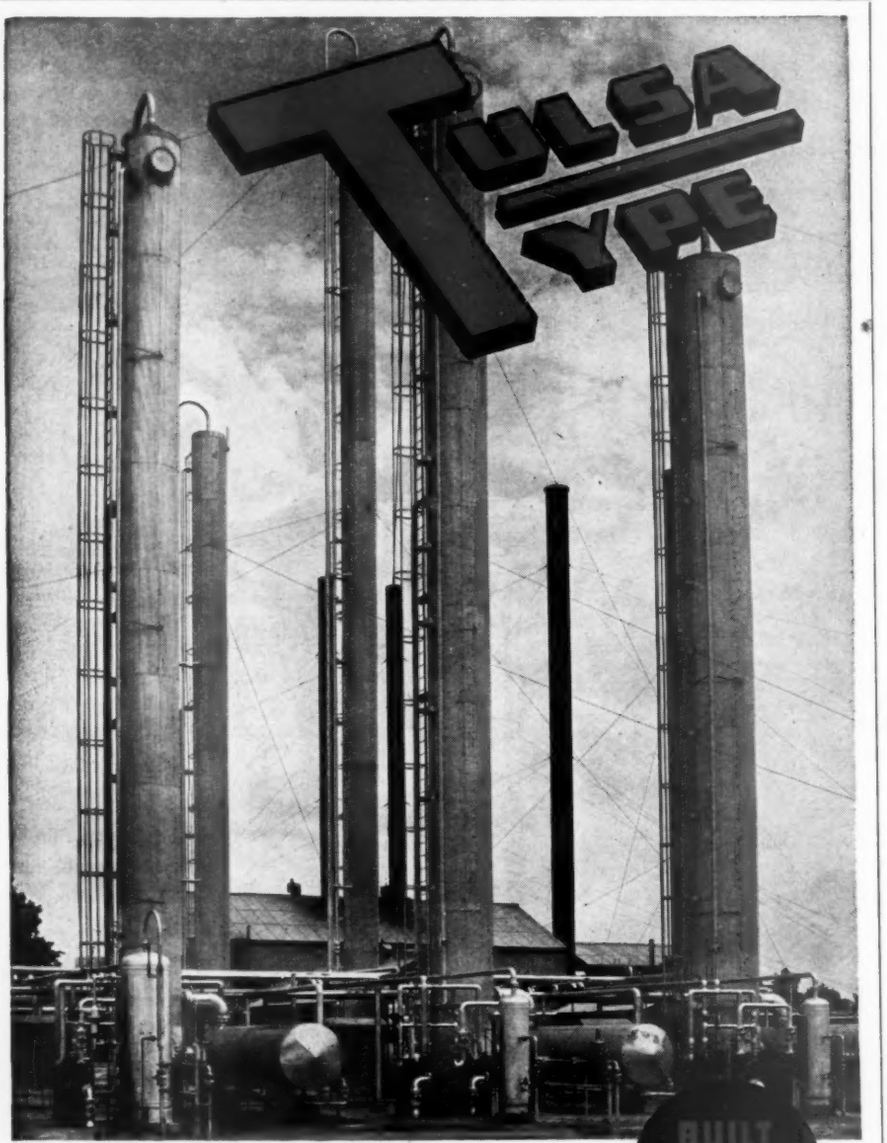
An impression gained during the progress of the larger scale work was that an equilibrium mixture of the olefins tended to be formed over the catalysts, the naphtha or pressure distillate octane rating then being 65-67. Treatments that resulted in products with a higher clear motor method octane rating were sufficiently vigorous to result in isomerization of the paraffins as well. Direct confirmation of this hypothesis was not obtained but it explains successfully the results obtained.

TABLE 6. Octane rating of shale gasoline-tar acid blends

Tar acids % by vol.	Clear		0.51 cc TEL/gal.	
	O.N. of mixture	Blending O.N.	O.N. of mixture	Blending O.N.
nil	64.9	—	69.7	—
2½	67.5	169	72.3	174
5	70.3	173	75.4	184
7½	72.9	172	77.6	175
10	74.2	160	79.0	163

TABLE 7. Sulfur contents of refinery products.
Per cent by weight.

Day of run	10	12	16
Pressure distillate	0.28	0.23	0.28
Atmos 1 overhead	0.103	0.09	0.11
Atmos 1 bottoms	0.33	0.30	0.37
Polymer gasoline	0.19	0.11	0.10
First stage acid treated gasoline	0.33	0.33	0.29
First stage acid treated gasoline after distn. to 375 F	0.23	0.27	0.19
Second stage treated gasoline	0.35	0.28	0.42
Second stage treated gasoline after distn. to 375 F	0.18	0.15	0.13
Atmos 11	0.13	0.15	0.12
Vacuum overhead	0.19	0.30	0.29
Doctor plant receiver	0.15	0.16	0.15
Line to storage	0.17	0.18	0.16



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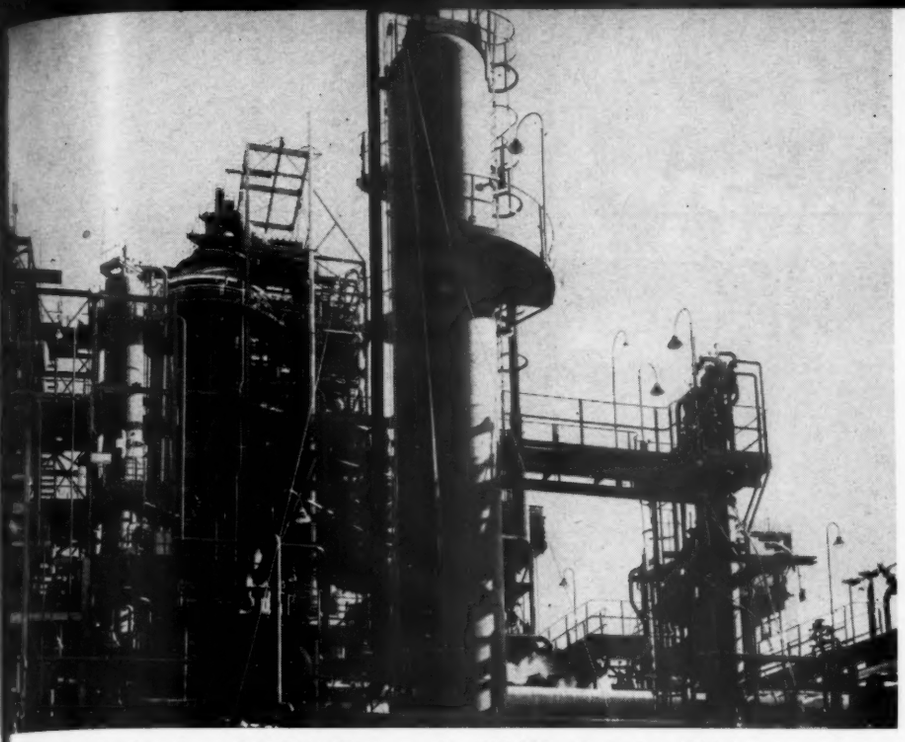

New Catforming unit at Point Breeze makes 500,000 gal per day of high octane gasoline from straightrun naphthas.

First East Coast Catformer on Stream

Atlantic begins $50,000,000, six-plant expansion and modernization program at Point Breeze, Pennsylvania

EUGENE B. BRIEN*

COMPLETION of the first Catformer on the East Coast, the first unit of a $50,000,000 modernization and expansion program to be completed at its Point Breeze, Pennsylvania, refinery has been announced. (Fig. 1). Other units slated for early completion are:

A 100-ton per day synthetic ammonia plant ($5,500,000);

A 35,000 bbl per day catalytic cracking unit, the largest of its type in the world ($12,500,000);

A 50,000 bbl per day pipe still with atmospheric and vacuum towers ($9,500,000);

A 3500 bbl per day aviation alkylate unit ($4,500,000) and a 10,000,000 gal per day waste disposal plant ($4,500,000).

At the same time, Atlantic is enlarging capacities of its two products pipe lines to Pittsburgh, Buffalo, and Rochester.

New Catformer

The Philadelphia Catforming unit produces 500,000 gal of high-octane gasoline per day from low-grade naphtha by isomerizing the paraffins in the feed and by hydrogenating the naphthenes to aromatics. By-products of the process are hydrocarbon gas and high-purity hydrogen. The Catforming process, the result of 8 years of research, components of the feed stock are changed as follows:

Components	Octane Rating	Proportion before Catforming, Per Cent	Proportion after Catforming, Per Cent
Aromatics	High	10	50
Naphthenes ..	Medium	40	4
Isoparaffins ..	Medium	25	28
Paraffins	Low	25	18

Two unusual advantages are reported for the process: It produces higher yields of higher octane gasoline than more conventional methods; and it does not change the molecular weight of the charge, so that there is almost no loss of volume in the products.

Central feature of the new unit is a new catalyst. The active catalyst ingredient in the three reactors making up the plant is 2680 oz of platinum in 40,000 lb of catalyst and valued at $250,000.

Catforming Process

The Catformer is charged with low-octane gasoline; mixed with hydrogen and heated to 900 F and compressed to 500 psig, the feed enters the first of three 9-ft diameter reactors filled with catalyst. About 50 per cent of the feed is converted to high-octane gasoline in this reactor.

As the reforming reaction is endothermic, the stream is reheated in a second furnace and passed through a second similar reactor where about 30 per cent of the remaining stream is reformed. Heated a third time, the remaining feed is reformed in a final reactor.

Effluent from the Catformer is then pumped to a high-pressure separator where it loses its hydrogen overhead. Some of the hydrogen is recycled and mixed with incoming raw gasoline, and the excess is withdrawn for fuel. Later the excess hydrogen will be used as a raw material along with nitrogen to make ammonia in the synthetic ammonia plant now nearing completion.

The bottoms product of the separator, containing high-octane gasoline and some hydrocarbon gas, is pumped to a stabilizer where the gas is fractionated overhead and the stabilized gasoline is withdrawn from the bottom. The gasoline is blended with other stock to make an easy starting, quick warm-up and good mileage product fit for the highest compression engines in the modern car, officials report.

Because of the 500 lb pressure of the process, the three reactors have 2.5-in. thick carbon steel walls lined internally with several inches of insulating cement, and is protected also by a stainless steel liner.

Other equipment making up the Catformer unit consists of a large battery of high pressure hydrogen compressors, necessary heaters and compressors to recycle hydrogen; a system to rerun the reformed naphthas; a catalyst reactivating heater; and a hydrogen purifying unit.

The new process is said to achieve an almost complete removal of undesirable sulfur and gum-forming compounds normally present in the raw gasoline used as feed stock.

Atlantic is constructing a similar Catforming unit at its Port Arthur, Texas, refinery. Nine other refiners are licensed by the company to build or operate similar units; licenses are open to the industry.

The design for the Point Breeze plant came from company engineers and plans and specifications were prepared by Stone and Webster Engineering Corporation. * * *

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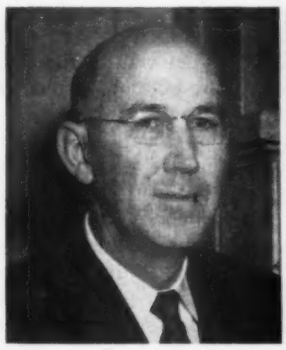

H. G. Owen

W. P. Gee

A. W. Baucum

Harold G. Owen, formerly process engineer at Continental Oil Company's Billings, Montana, refinery has been appointed staff engineer of the petrochemicals division, Continental Oil, Houston, Texas. Before going to Billings, Owen was regional technologist for Continental's Rocky Mountain region, Denver, Colorado.

William P. Gee, assistant to the president, has been placed in charge of all petrochemical activities for The Texas Company.

Gee also will be responsible for the company's activities in the field of synthetic rubber, the announcement stated. He represents Texaco as a director and member of the executive committee of Jefferson Chemical Company, in which Texaco has a 50 per cent interest.

Gee entered the oil business in 1919, and was first employed by Texaco in 1927 as a research chemist. In 1947, he was elected vice president of Texaco Development Corporation in charge of process licensing, and remains a director of this company. In 1951, he was appointed assistant to the president.

Also announced was the appointment of **A. W. Baucum** as assistant to the president. He has been assistant to the vice president in charge of the producing department since 1950.

Baucum was graduated from Texas A. & M. College in 1934, and joined Texaco the same year. In 1946 he became assistant division manager of the South Texas division, and in 1948 he was appointed assistant to the manager of the producing department, Houston. He was transferred to New York in 1950.

Dr. Paul S. Stutsman, supervisor of chemicals research at Texaco's principal research laboratories at Beacon, New York, will be transferred to Gee's office to assist in over-all company activities relating to the development and production of petrochemicals.

Thomas J. McDermott, shift foreman at the General Petroleum Torrance, California, refinery, has retired after nearly 37 years of refinery service. McDermott was shift boss on the original stills at Torrance when the then tiny refinery first went "on stream" February 22, 1929. His entire service, since 1917, has been in refinery operations at both Vernon and Torrance.

Joseph W. Moorman has joined the catalyst division of the National Aluminate Corporation. He has been active in the cracking catalyst field since its inception, both from a design and operational standpoint. He was associated with M. W. Kellogg Co. during the development of the fluid catalytic cracking process. He is a graduate of the University of Tulsa, Oklahoma.

Carl S. Reed has announced his retirement as chairman of the board of directors of The Lummus Company. Reed succeeded **Walter E. Lummus** as president of The Lummus Company in 1931 shortly after its incorporation as a successor firm to The Walter E. Lummus Company.

J. F. Thornton succeeded Reed as president of the company in 1951.

Ovid Baker has been named chairman, Dallas Chemical Engineer's Club. Other officers include **Howard Kock,** vice chairman, and **Harold Blum,** treasurer.

Dan Schoenholz has been promoted to director of the product development department of Foster D. Snell, Inc. Schoenholz joined Snell in 1944 and has been a research group director in charge of wax, paint, and varnish work.

Bernard Berkeley will act as assistant director of the product development department. He joined Snell in 1944 as a chemist and has been a group leader in the field of chemical specialties.

Leo V. Steck, vice president, Shell Chemical Company, was selected as the recipient of the 1954 CCDA honor award conferred by the Commercial Chemicals Development Association, in New York, March 18, 1954. Several achievements of major proportions are attributable to Steck, said CCDA President W. E. Kuhn, The Texas Company, in the presentation address.

A pioneer in the development of commercial petrochemicals, Steck successfully marketed ketones for use as lacquer solvents by bringing methyl ethyl ketone from the test tube to the 20,000,000 gal sales volume of 1953.

It was largely due to his personal activities that the hot chlorination of propylene to allyl chloride successfully emerged from the laboratory.

Large scale production of allyl chloride made epichlorohydrin possible, which in turn led to the epoxy resins. Recognizing the unusual properties of the resins, Steck developed a market for them, underwrote construction of the first commercial plant, and greatly expanded their uses. He had the satisfaction of seeing their production move from half a million pounds in 1946 up to 25,000,000 lb in 1953, a volume requiring about 10,000,000 lb of epichlorohydrin.

Steck helped foster the first semi-scale pilot plant for the production of butadiene from petroleum gases via dichlorobutane. His activities led to the first commercial unit in 1941, which supplied the bulk of the butadiene for the original extensive experimental work on synthetic rubber. This indicated need for butadiene, made by dehydrogenation of butylenes.

Steck stressed need for trained personnel in industry in his acceptance address.

L. V. Steck, vice president Shell Chemical, recieves 1954 honor award of CCDA from Dr. W. E. Kuhn, president, and manager of technical and research division, Texaco. R. C. McCurdy, president of Shell Chemical Corporation, smiles approval.

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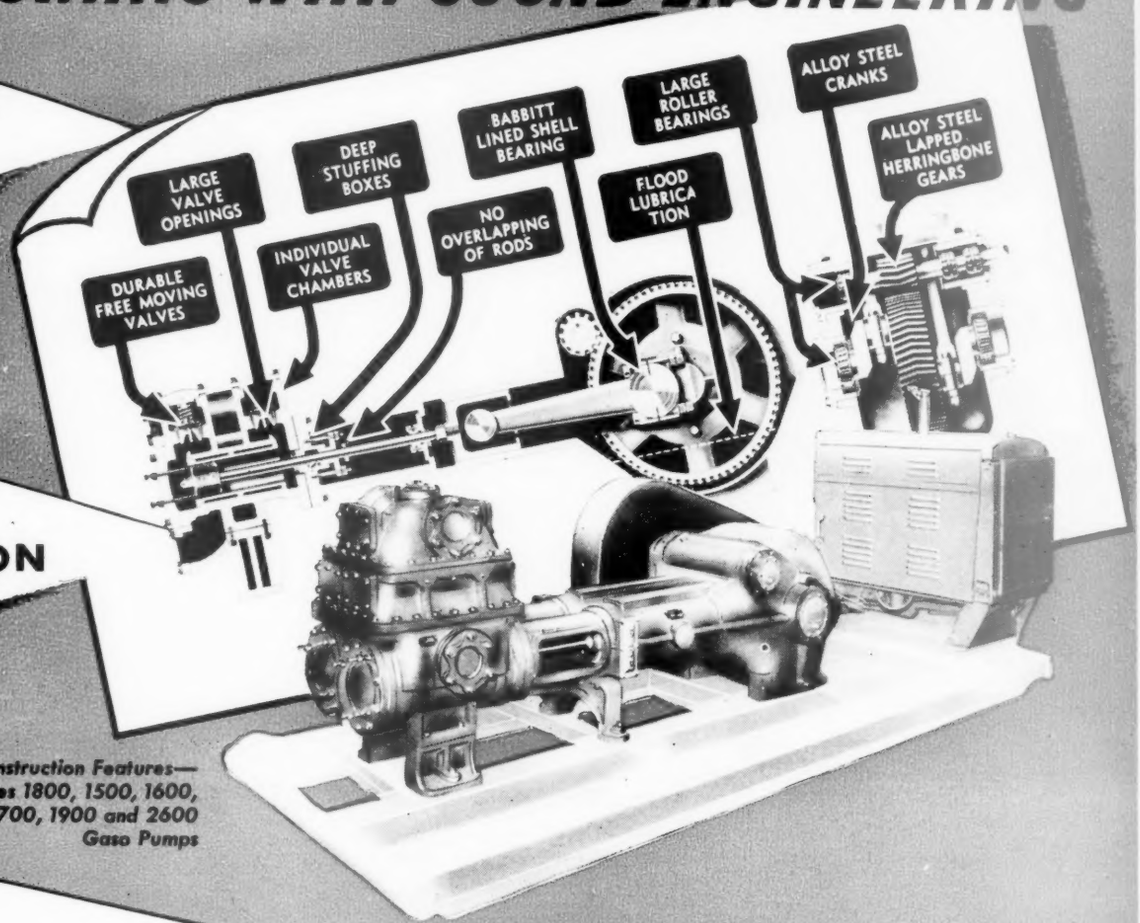

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The pipeline strainer that cannot be cleaned quickly and returned to service, necessitating by-passing, is little better than no strainer at all. Jet Type Fluid Strainers utilize a jetting action of high pressure fluid to clean the stainless steel wire cloth strainer element. Thus, a strainer may be cleaned perfectly and returned to service in from three to five minutes. So, when a strainer is needed most . . . immediately before the arrival of a scraper . . . you can depend on Jet Type Fluid Strainers to stay on the line and clean all the product.

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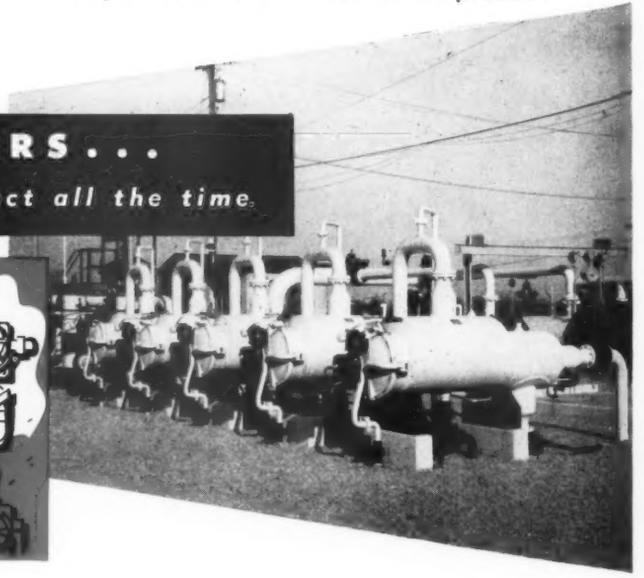

Right—Five 30,000 bpd Jet Type Fluid Strainers installed in a products pipeline terminal. Inset—The control panel for this installation includes pressure differential gauge for determining when strainers need cleaning, and control switches for jet cleaning.

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Realistic Rate Policy

A new, realistic rate policy has been used for the first time by the Federal Power Commission in granting rate increases to natural gas pipe line companies that own and develop natural gas reserves.

First use of the new policy, termed "controversial" by lobbyists for consumer groups, was in Panhandle Eastern Pipe Line Company case, which was given a rate increase for $12,778,-864, as compared to the $21,400,000 increase originally sought.

The commission ruled for the first time in its history that a company's rates should reflect the "fair field value" of its gas reserves.

New policy will encourage exploration, development, and production by pipe line companies, the commission majority asserted. It described the new policy as sound, and as one that will serve the public interests.

Dissenting commissioner Claude L. Draper said the new policy "can mean only increased costs of gas to consumers." Rep. Charles Oakman (R) of Michigan called the decision a "grab" by Panhandle and said it will cost consumers "billions of dollars."

FPC officials said there is no way of telling how many gas companies might seek higher rates under the new policy. One official estimated that only 15 to 20 per cent gas reserves are owned by companies that produce and transport in interstate commerce.

Only those companies producing from their own resources can qualify, but this can be a considerable number.

This "realistic" viewpoint in deciding fair values has long been needed. Consumers should be just as interested in future reserves as the supplying companies. If present reserves should "run out" say, in 10 years, and the companies have not kept up their exploration and development to provide new reserves, both consumers and suppliers will suffer. Development of new gas reserves is costly, and is undertaken in terms of today's values.

Trend of current valuation is not new. A quick look at real estate values and prices on consumer goods will support such a statement. Natural gas, as are other minerals such as coal, iron, copper, etc., must fairly be considered at present worth.

Adoption of new policy will tend to spur gas companies toward expanded development programs that can ultimately mean better service to more people in the future.

Revenues Up in '53

In a report covering all four quarters of 1953, Interstate Commerce Commission reveals transportation revenues of 57 pipe line companies reporting as interstate carriers showed a five per cent increase over 1952.

Biggest increase was attributed to Toronto Pipe Line Company, which reported $2,182,201 for 1953, a 132 per cent gain over its 1952 revenues of $940,287. Largest decrease in revenues was accounted for by Tide-Water Pipe Line, which dropped from $785,684 in 1952 to $352,005 in 1953.

Biggest carrier, based on number of barrels originated and received from connections was Humble Pipe Line with 272,253,401 bbl in 1953—13 per cent lower than Humble's 1952 total.

Top ten carriers in barrels carried included Gulf Refining, 249,950,613; Texas Pipe Line, 207,768,186; Interstate Oil Pipe Line, 185,349,973; Service Pipe Line, 182,664,234, Buckeye Pipe Line, 179,369,532; Sinclair Pipe Line, 176,174,818; Magnolia Pipe Line, 175,576,366; Ohio Oil, pipe line department, 167,325,081; and Shell Pipe Line, 144,453,307.

Overall, the total barrels handled by 57 companies in 1953 was 3,554,048,-844, over 1952's 3,294,416,788 bbl.

In The June Issue You'll Find...

... articles by operating men written especially for operating men on the latest in operating practices, including:

... **Pipe Line and Terminal Losses** cost the industry $14,000,000 annually. In a sequel to their May article, authors Baird and Rankin discuss how Wyco Pipe Line Company cut its losses to a minimum.

... **Rush Order! Two New Platte Stations** boost capacity of Platte Pipe Line System, are latest in architectural design, functional in operation.

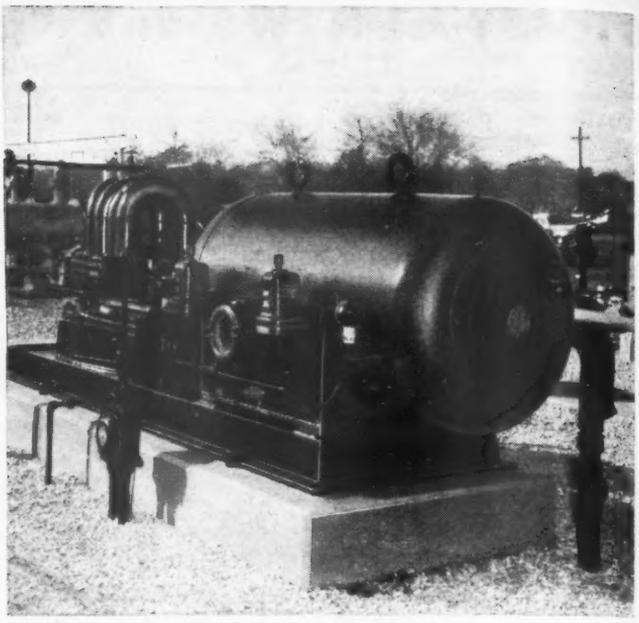
... **Modern Tractor Equipment** includes a variety of accessories, essential items that users should know about. Review of what, when, why and how to use it.

... **Microwave System Design,** part two of a series, discusses initial phases in the planning and design of a microwave communications and control system.

Read these and other engineering, operating and design articles in your June *"Oil and Gas Pipelining"* Edition.

"YOU AND YOUR CRAZY, MIXED UP, PIPE-LOCATOR!"

TRI-CLAD* VERTICAL explosion-proof motors, like these belonging to Pan American Pipe Line Company and located adjacent to Rancho Pipe Line System's Eldorado Station, are available to suit the requirements of the pump mounting. This is just one of G-E's complete line of pipe-line motors.



TOTALLY ENCLOSED EXPLOSION-PROOF motors have been tested and listed by Underwriters' Laboratories for Class I Group D hazardous locations. Like this one at Sinclair Pipe Line Company's Clinton Station, they withstand all weather conditions, do not require firewall.

G-E Pipe-line Motors Can Help You Reduce Your Maintenance and Inspection Costs

For the vital, continuous service which pipe line pumping requires, specify G-E motors. You can install them in your isolated stations and forget them for months at a time—because their rugged construction and high quality materials are designed specifically for long, dependable life in pipe-line service.

Wide selection offered by G.E. assures you the best motor for the job. For special applications, G.E. has the engineering experience necessary to design and build motors to meet your special requirements.

G.E.'s application and field engineers can serve you as a staff of experts on all your electric pipe-line equipment—to give you a co-ordinated, well-balanced system. And no matter where your pipe line reaches, you'll find G-E sales and service facilities all along its path to help you keep your throughput at a maximum under all conditions.

For more information, contact your G-E Apparatus Sales representative. *General Electric Company, Schenectady, N. Y.* 830-2

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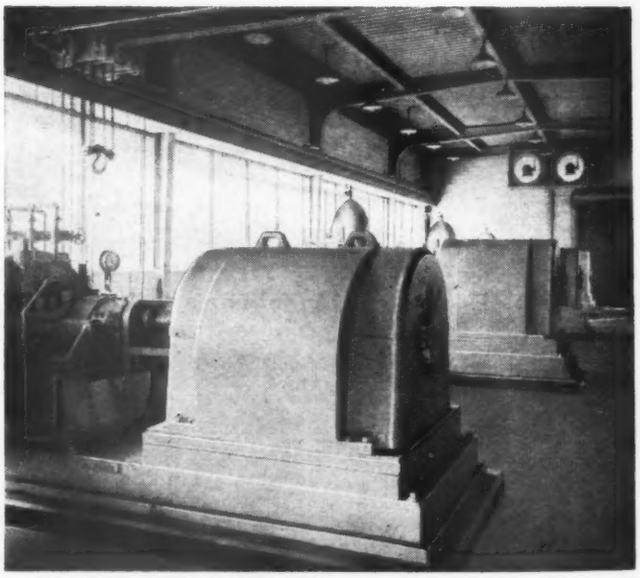

BASE-VENTILATED MOTORS up to 3000 hp may be force-ventilated like these at Rancho Pipe Line System's Garfield Station. Separate blowers are started in advance to purge motor and duct system.

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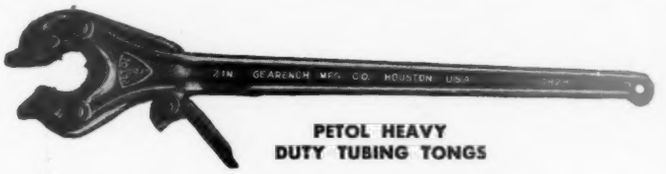
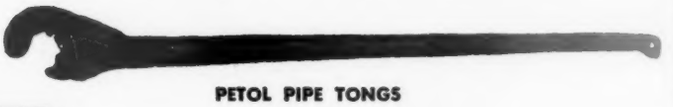
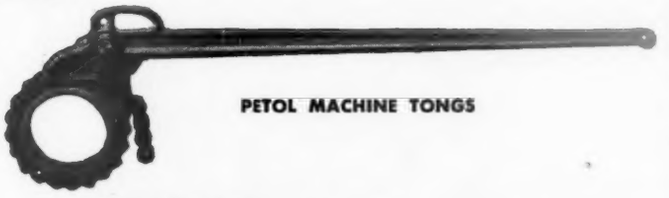


PETOL HEAVY DUTY TUBING TONGS



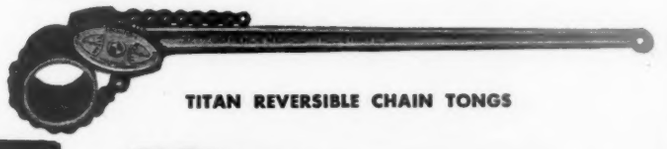
PETOL PIPE TONGS

TITAN PIPE TONGS



PETOL MACHINE TONGS

TITAN CHAIN TONGS



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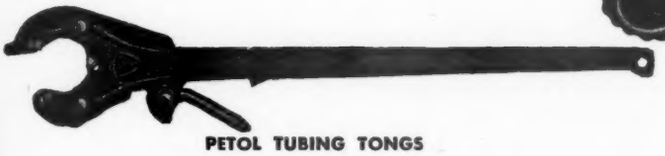

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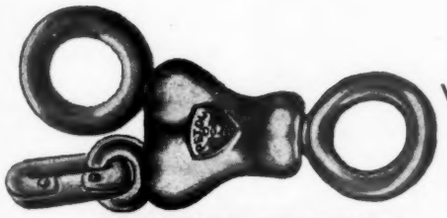

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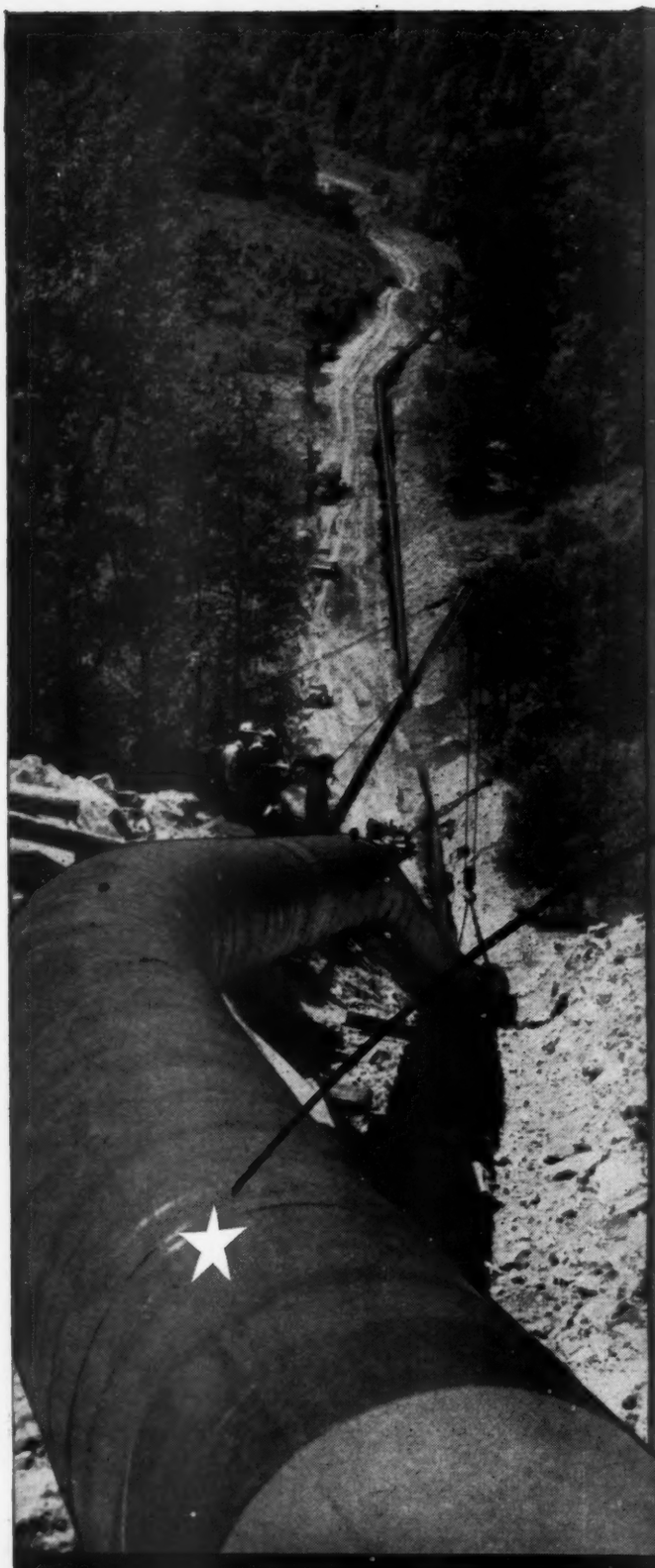

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Before you specify the coating for your next pipe line, check the many reasons "Why" it will pay you to select Dearborn NO-OX-ID Pipe Coatings and NO-OX-IDized wrappers. A Dearborn pipe line engineer is available for consultation.

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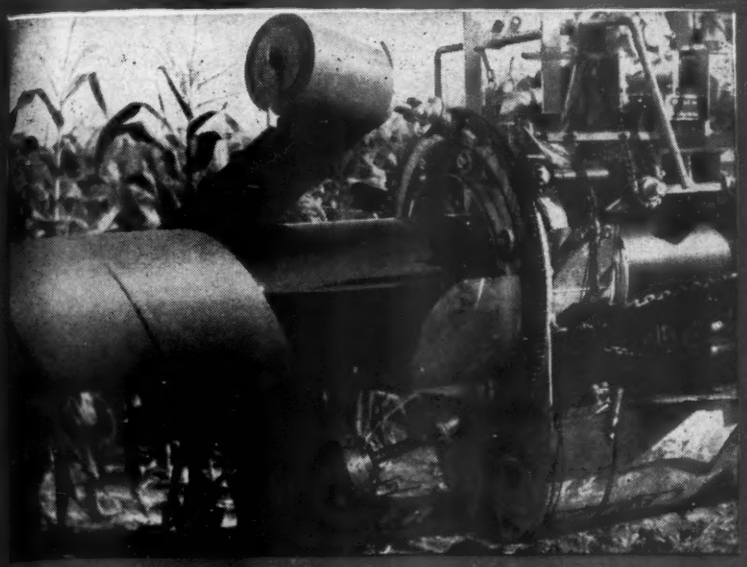
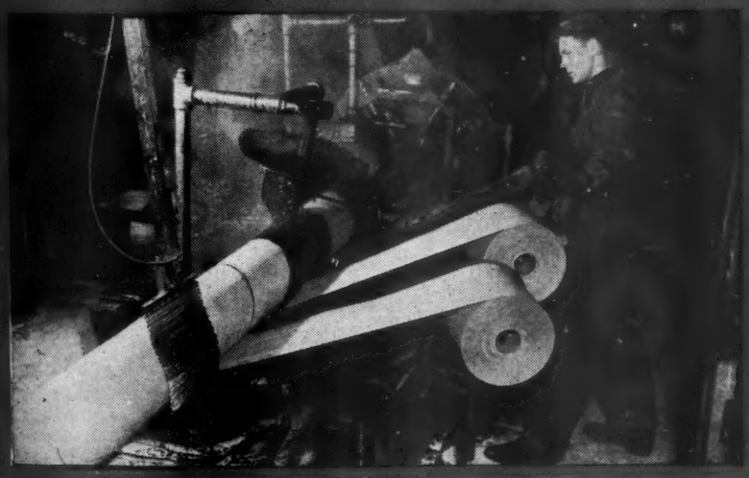


by Traveliner

On long lines, traveling machine application of NO-OX-ID and NO-OX-IDized Wrappers produces greater footage with smaller coating crews. NO-OX-IDs do not produce noxious or harmful fumes.

by Hand

Over rough terrain—on short lines—on maintenance jobs, Dearborn NO-OX-ID and NO-OX-IDized Wrappers are easily applied either cold or hot. A NO-OX-ID coating of only 1/32" is adequate for long term protection.



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Independent applicators and many utilities rely on NO-OX-ID combinations applied by stationary coating machines for *complete* pipe line protection.

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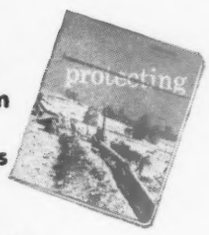
Dearborn has specialized in the control of corrosion and the conditioning of water since 1887. This broad experience—plus Dearborn's extensive research and laboratory facilities—are at your service...at no obligation. You'll find it will pay to know your Dearborn engineer.

FOR YOUR FILES...

This informative Dearborn book "Protecting Underground Pipe from Corrosion with NO-OX-ID and NO-OX-IDized Wrappers." Illustrates and describes all methods



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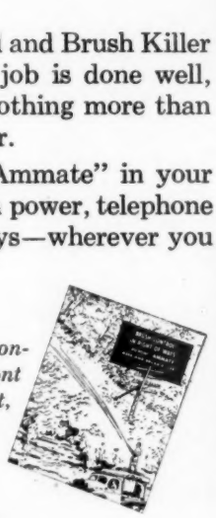
LESS LABOR KILLS more brush at lower costs when you use "Ammate." It kills more kinds of brush than most weed and brush killers and keeps brush down longer!

AFTER THREE YEARS—Here's the same right-of-way as shown at left. Brush still remains under control, yet low-growing natural cover returned to resist erosion.

How to keep brush down for years!

Industrial users of "Ammate" Weed and Brush Killer say that when the original spray job is done well, brush is kept under control with nothing more than an occasional spot spray years later.

This year, be sure to include "Ammate" in your brush-control program. It's ideal on power, telephone pipe-lines and railroad right-of-ways—wherever you have a brush problem.



Free illustrated booklet *describes how to control brush in right-of-ways with Du Pont "Ammate." For your copy, write Du Pont, Grasselli Chemicals Department, D-4026, Wilmington, Delaware.*

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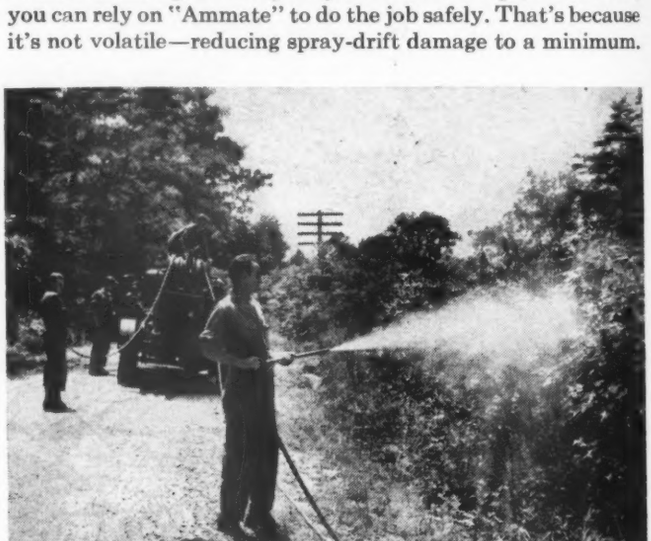
On all chemicals always follow directions for application. Where warning or caution statements on use of the product are given, read them carefully.

EVEN WHERE right-of-ways adjoin sensitive crops, like cotton, you can rely on "Ammate" to do the job safely. That's because it's not volatile—reducing spray-drift damage to a minimum.



MAINTENANCE CREWS and custom sprayers prefer "Ammate" for faster, safer, longer-lasting control of brush. And they can use it without hazard to themselves, livestock or wildlife. "Ammate" is non-flammable, too.

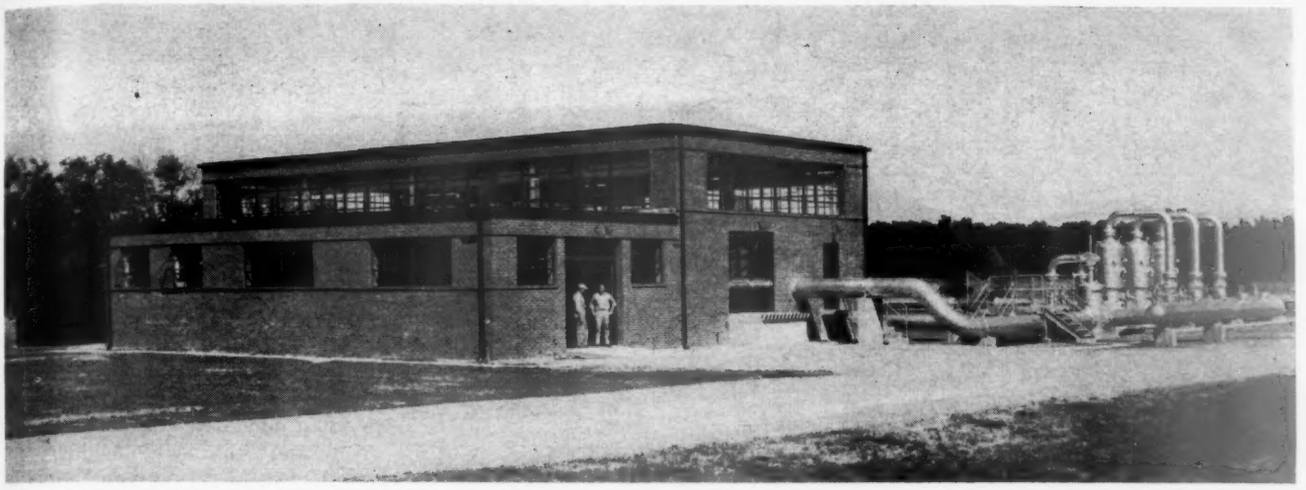


FIG. 1. A modern centrifugal compressor station on a 30-in. natural gas pipe line. Clean, simple lines in design, steel and masonry construction, are representative of the "New Look" in today's pipelining.

A combination of engineering, economics, and sound business management is working steadily to produce a

"New Look" for Pipelining

DEAN HALE*

PIPELINING, 1954, is a far cry from pipelining, 1865, when the first successful crude line was put into operation, and the first gas company was organized. That first five-mile, 2-in. wrought iron line in Pennsylvania had a capacity of 800 bbl per day, operated at 200 psi, and used three steam-driven pumps. The first successful, leak-proof gas line was 5-in. line built by S. R. Dresser in 1891, using couplings he developed and which still bear his name.

From these early beginnings, pipe line transportation of crude, refined products, and natural gas has developed into a major transportation medium of nearly 600,000 miles of line and one of the nation's largest industries. In recent years, the pipe line industry has begun taking on a "new look," a transition from its earlier "rough and ready" school of thought. Current trends are toward the use of advanced equipment, design, engineering, and operating practices, all aimed at efficient and economical operation.

The pipe line industry grew like Topsy from the beginning. In the 35-year period ending in 1900, 18,000 miles of crude lines fanned out in all directions from the Pennsylvania fields. Advent of "leak-proof" lines for gas service boomed that industry. Emphasis was on building the line and delivering the product, with little if any thought given to equipment necessary. There was little standardization of equipment and little thought lent to improving practices.

In the 1920's, a new trend began, and designs of lines toward improved operations became the keynote. In the period up to the beginning of World War II, big-inch lines came into being, station equipment was modernized, adequate communications became necessary and the concepts of pipelining were greatly changed.

Technological advances in the industry were given a boost during the war with the building of the Big and Little Inch lines. Since the war, great strides have been made in every phase of pipelining. Bigger and longer lines have been built, more and more remote and supervisory control systems designed, use of microwave and radio has increased for both control and communications, corrosion mitigation has become vitally important, construction technique have advanced, and research has contributed much to better operations.

Predicting what pipelining of the future will be like is difficult, to say the least. Industry leaders agree that more improvements will be made, and all will contribute to the end that is inevitably sought — efficient and economical operation.

To cover thoroughly all that has been done and is being done would take volumes. In the following columns, however, will be found a brief summation of trends and developments that reflect the growth and importance of today's pipe lines.

Economic and Market Studies

Designing, building, and operating pipe lines has become a scientific procedure, so to speak, within the industry, and has been such for a number of years. Preceding these steps, though, is the study of requirements and the decision to "go ahead," a procedure that has sometimes been arbitrary and in some cases resulted either in inadequate or surplus facilities.

Pipe lines aren't just built. It is first necessary to know where, when, why, and how to build a new line or modify

*Editor, Oil and Gas Pipelining.

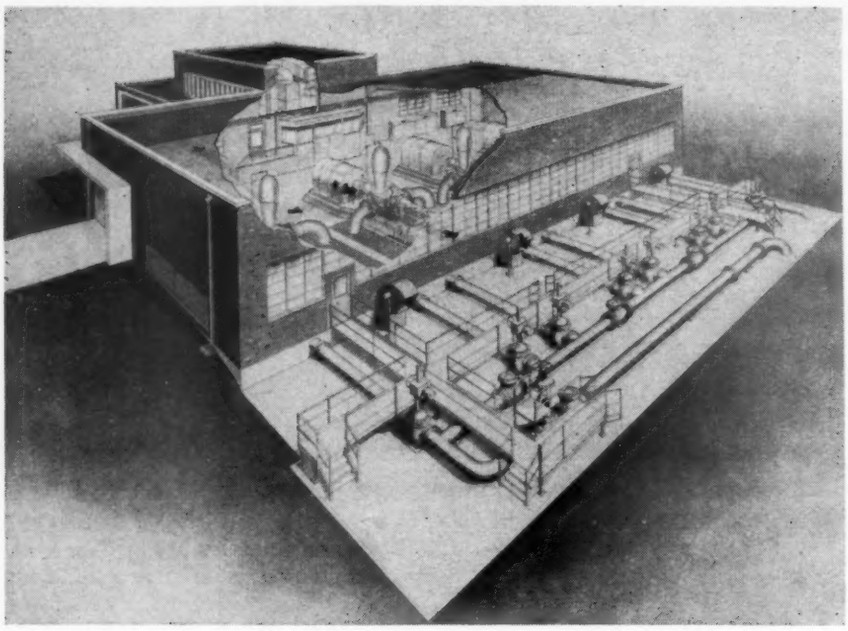


FIG. 2. Cutaway drawing of modern pipe line pumping station, showing arrangement of pumping equipment and details of the manifold system. Valves, foreground, are electrically operated by remote control from within station. Architecture of station is in keeping with the "New Look."

existing facilities. This requires careful evaluation of all factors, including supply of the product to be carried (crude, gas, products), marketing of the products, line size, stations, and other facilities, all affected by many different variables, in order to determine a reasonable return and payout.

Too often studies of all these conditions have been inadequate and decisions made without completely conclusive data.

Overcoming this policy, companies now are making extensive studies of all pertinent economic conditions, followed by an intensive study of data accumulated, before making a decision.

Notable is the work of one products pipe line, which has been studying its market area for some time, studying, over a period of time, every factor affecting its operation, including weather conditions, demands for products according to seasons, farming practices, househeating practices, and distribution practices.

Weather is probably the most important factor. Cold means increased use of heating fuels, warmer means greater use of automobiles and farm equipment. Long range weather determines farming practices and, subsequently, fuel demands by rural consumers. Studies are being made of individual practices of both city and rural residents in relation to their consumption of petroleum products and how affected by weather. Distribution practices of the pipe lines shippers are also surveyed, to find weak and strong areas, and why so.

Information accumulated is given a mathematical relationship and through use of electronic computor, requirements of each area are determined and such information is supplied the various shippers. The method was developed after a preliminary study more or less proved that shippers were't able to predict their own future needs. The pipe line inaugurated the service to protect itself.

Similar methods are also being employed by several crude transporters. Natural gas companies are also applying detailed studies to their operating problems, although federal regulations determine their practices to a large extent.

Construction

Tedious, time-consuming ground surveys for initial planning of pipe line routes have been almost entirely replaced by aerial surveys. New techniques in mapping working from aerial surveys have made pipe line alignment sheets easier to draw and use, at considerable savings in time and money.

Weather has long plagued the pipe line project. Companies and contractors are now taking advantage of meteorological information in the form of short and long-range forecasts to plan their work and utilize to a maximum their equipment and manpower.

Welding practices have progressed to a point where the "stovepipe" method of welding, pipe joints, using internal line-up clamps, is almost universal today. Submerged-arc welding, a recent development, is used when double-jointing pipe in a central yard, before moving to right-of-way. Radiographic inspection of welds has become an accepted practice, generally on all welds in a river crossing and "spot checks" on the remainder of the main line. This method is also used to test weld quality of welders before employment.

Practically every line laid today is coated in some manner, and usually wrapped with both glass fiber and asbestos felt. For crossings in marshes, swamps, rivers, and open water, concrete-type coatings are used to supply additional negative buoyancy. Use of river clamps is another method of providing added weight.

New and improved machinery for pipe line construction is continually being developed, with much of the progress attributable to "on the job" modifications by the pipeliners of existing equipment.

Hydrostatic testing of completed lines in place is another practice becoming widely accepted. Several major pipe lines constructed in 1953 were tested in this manner and results were very satisfactory. For gas line construction, a new piping code will require this type of testing in certain areas.

Corrosion

Field studies and laboratory research are teamed together in producing materials and equipment for corrosion mitigation. Improved coatings and wrappings are now available and, with proper application, aid materially in reducing corrosion costs. On existing lines where other preventives cannot be used, cathodic protection is being applied satisfactorily. Internal corrosion is being combatted through various types of linings and inhibitors. In gathering lines and city gas distribution systems, plastic and aluminum pipe show possibilities as a means of reducing corrosion.

Fluid and Gas Flow Research

As lines increase in diameter, it is necessary to know the characteristics of the product being carried. The theories of hydraulic and gas flow are important to the design engineer so that he can accurately size lines, machinery, pumps, valves, and other equipment. A great deal has been done in recent years and more extensive studies are planned or underway. Pressure surges, which are damaging throughout a pipe line system, are being given exacting study by several companies.

Station Design

Architecturally, stations built today are designed not only to be pleasing to the eye, but also to be functional in nature. The old standby, the corrugated iron or prefabricated building, is

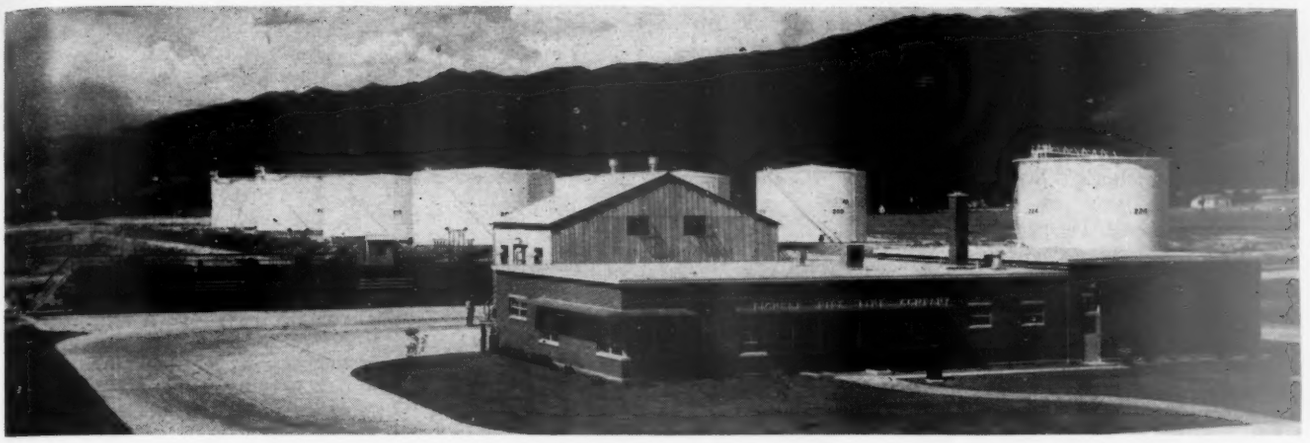


FIG. 3. Modern products pipe line stations and terminals are functional in design, incorporate latest in engineering techniques.

being replaced with compact masonry units. The station, once used only to house equipment and machinery, now also serves as a control center, and in some instances pumping equipment of weather-protected design is located outdoors.

Prime Movers

One of the greatest changes in pipe line equipment is the type of prime mover used, which today includes electric motors, gas-turbines, steam-turbines, and diesel engines, with the latter adapted for use as full diesel, dual-fuel, or tri-fuel engines operating on diesel fuel, fuel-gas mixtures, or straight gas. A newcomer to the field is the free piston engine. In gas compression, a complete engine-compressor unit operating on gas is available. Choice of prime mover is dependent upon economics, and units of many types can be found at various stations on the same line.

Pumps and Compressors

Big, slow plunger pumps for moving crude oil have been replaced by multi-cylinder, high-speed reciprocating pumps and centrifugal pumps connected directly to the prime mover or through speed changers. Centrifugal pumps with enclosed weather-proof electric motors also have proved themselves well-suited to outdoor applications, such as booster pumps to provide proper sump suction head where tankage is used.

Large, slow reciprocating compressors are also being replaced by higher speed units and centrifugal compressors, although many of the former are still in use and preferred. The engine-compressor unit has found a wide application. Advances in compressor design continue to give increased performance per applied horsepower.

Communications

In a few short years, microwave as a means of communication and as a medium of automatic control has been widely accepted. It is used extensively in dispatching and transmission of messages. Mobile radio systems, allowing contact between central stations and mobile units installed in trucks and automobiles, have increased operating and maintenance efficiency. Wire line communications have been broadened with the advent of carrier systems, allowing operation of as many as 16 telegraph or teletype channels and up to 12 voice channels over a single pair of wires.

Automatic Controls

Control systems of every conceivable type are being used in pipe line operations, including remote control of stations, supervisory controls systems, and telemetering. Through their use, the dispatcher can "keep tab" on an entire system, coordinate all activities for greater utilization of the system's facilities.

In crude and products line dispatching, it is essential to know the exact location of the interface. Recently developed devices and techniques such as radioactive tracers, improved gravitometers, and the capacitance-recorder are proving valuable.

Automatic samples at reception and delivery points help obtain a representative composite of the various batches. From these samples, gravity readings and the BS&W level are determined. Automatic samplers can be set and will deliver a minute amount of crude oil into containers over a long period of time.

Underground Storage

In order to meet peak demands and assure uniform flow despite seasonal fluctuations, a large number of gas transportation and/or utility companies are now developing underground storage facilities for natural gas. Initial development was limited to exhausted gas and oil fields for storage facilities. Salt domes and similiar geological structures have also been utilized, and studies have been made of abandoned quarries and coal mines.

Electronic Devices

The scope of electronics is far too great to cover here, but a few unique achievements can be mentioned, among them being the use of electronic computors to simplify the task of making calculations from tremendous amounts of data. Problems are reduced to mathematical formulas and solutions are obtained by feeding necessary information to the computor, which delivers solutions in a fraction of the time required if the task were done manually.

An electronic "gadget" proving successful is a remote gaging device employing a voice drum, on which "spoken" measurements are magnetically recorded similar to wire or tape recordings. The dispatcher pushes a button in his office and the drum, synchronized to an automatic gaging device, gives him a direct reading in feet, inches, and fractions of an inch, and tells him the tank number, all as though a man were at the other end of the line reading the information. The device can be connected to any number of tanks to be read. It was developed and is in use by a products pipe line.

Ultrasonics, the field of high frequency sound, which have been used in inspection of pipe lines, are being studied for application as a check on river crossings of lines in operation. An ultrasonic device that would immediately detect drops in pressure resulting from small pinhole leaks that cannot be recorded on high pressure gages is under development.

Another electronic device being studied is an electronic counter that could be synchronized to meters for checking flow in or out of tanks. Any number of meters could be connected to the counter. Starting from zero, the counter speeds through a series of

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units until it is synchronized with the meter, doing so in a fraction of a second. It would be attached to a printer, giving a record of the meter reading, time, date, and any additional information required. It could be operated from the dispatcher's office.

Automatic Terminals

Within the realm of possibility and probability are automatic terminals for products pipe lines. Loading racks for trucks would have automatic metering, with printed records made of amounts loaded and all other pertinent information, including special safety devices to prevent theft. Flow through small lines to service stations within a reasonable radius of the terminal would be metered and recorded.

Handling of products and use of manpower would be kept to a minimum and could be directed from a central office many miles away through use of modern communications.

Public Relations

Increased activity on the part of pipe line companies to build good public relations has been noted in recent years. Landowners over whose property the pipe lines traverse are being wooed through soil conservation programs, company magazines, and generally good fellowship between the landowner and representatives of the pipe lines.

The importance of the underground arteries of commerce has been stressed in advertising, newspaper and magazine articles, and good relations with civic and governmental bodies.

Unlike other forms of transportation, whose modes of movement are evident to the eye, buried pipe lines have only scattered pumping or compressor stations and the personnel they employ. These personnel are helping build a good name for the pipe lines through their activities, both in business and community life.

Maintenance

Much of the progress of the pipe line industry can be attributed to improved maintenance practices, without which design and operation are valueless. Important to maintenance is the use of modern and adequate tools, improved methods and techniques, and proper management.

Down time due to repair or replacement of parts or complete engines, compressors or pumps, and auxiliary equipment, has been reduced from days, as in the early days of pipelining, to a matter of a few hours, mainly through the use of adequate tools and equipment. Having them available at all times means quicker action when they are needed and better work from

FIG. 4. Construction methods have been greatly improved in recent years. Constructors take advantage of formerly detrimental weather conditions, use bigger, better equipment, and modern practices to lay lines at rapid pace.

employees, who can do a better overall job with less physical effort and have sufficient time to think the task through.

Cleaning Gas Lines with Water

Most gas pipe lines that have been in service more than five years are not equipped with full opening valves and scraper traps for on-stream cleaning. Shut-down cleaning of these lines is time consuming and often requires 20 runs with the dry pigging method.

A method designed to produce maximum flow efficiency with minimum shut-down time has been developed by El Paso Natural Gas Company, using water and detergents. Three to four runs are required, one exploratory, one detergent, and one or two rinse runs. Efficiency increases as high as 15 per cent have been reported. Little if any water is left in the pipe line and no trouble due to this cause has been reported on more than 500 miles of cleaning accomplished to date.

Other Pipe Line Uses

Backbone of the oil and gas industry, pipe lines as a means of transportation are not necessarily unique to those industries. Other applications have been tried, some successfully and some not so successfully, and even at present, newer and more far-reaching uses are being visualized.

Coal Pipe Line. Experimental operation of a demonstration-size pipe line of 12¾-in. diameter pipe is being conducted in Ohio. Coal is crushed to a fine size and mixed with water to form a slurry, which is pumped through the line under pressure.

Paper Pulp Line. Successful operation was conducted in Canada in which ground paper pulp in flush form was transported in a 2-mile line of 10-in. diameter.

Ore Pipe Line. Bulk concentrates of nickel-copper ore is being pumped through a 7½-mile line in pulp (or slurry) form, reducing the time required to transform the ore into refined nickel through quicker movement from mining and processing site to reduction plants. Economics resulting from use of pipe line for transportation have made possible the working of lower grade ores. The pipe in use is wooden, and flow is approximately 1100 bbl per hour of slurry.

Cement Pipe Line. Transportation of cement in slurry form over long distances from quarry to processing plant site has been proposed. Methods of keeping the slurry from settling or choking the line and means of boosting pressures at intermediate stations have been developed.

Pipe Line Transportation of Potash. A method of transporting potash over long distances by mixing with crudes has also been proposed. Potash would contaminate crude in a closed system and can be easily separated.

Chemical Pipe Lines. Small diameter lines of short distances, steel, aluminum, or plastics are either in operation or proposed and those now in use are quite successful. Long distance lines capable of handling numerous types of chemical fluids of varying viscosity and type have been envisioned and could be practical through use of plastic or plastic-lined metal pipe. Lines would originate in areas where basic chemicals are originated and transported to distant manufacturing areas.

Obviously, no discussion of all developments in an industry as extensive as pipelining can be touched upon in limited space. In this Progress Number of *The Petroleum Engineer* will be found many articles on developments that are helping give pipelining a "New Look." ★ ★ ★

Product Pipe Lines and Terminals:

CONSERVATION OR LOSS?

D. L. RANKIN and E. H. BAIRD

Large losses suffered by the industry in transporting, terminaling, and loading finished products is a national economic loss. It should be recognized that most of the ideas contained in this article are not original; however, because of the tremendous growth of product pipe line systems requiring increased personnel in the pipe line phase of the industry, they are believed to be timely. This article and one appearing in the June issue are written in the hope that they may be informative and will result in aiding some operators in reducing their loss or solving a loss problem.

THE handling loss of finished refined products, from the time tenders are accepted by a pipe line at origin until the products are loaded into tank cars or transport trucks at terminal destinations, is ever present and is one of today's major operating problems of all pipe line companies. Every effort must be made to deliver to the consignee as closely as possible to 100 per cent of the products tendered. The volume of products not delivered to the consignee contributes to the total industry loss.

Additionally, in many pipe line tariffs, transportation revenue is based on the volume the pipe line carrier delivers to the consignee and not on the amount the pipe line accepts from the shipper at origin. It follows, then, that the greater the handling or operating product loss the greater the reduction in transportation revenue suffered by the pipe line company.

To minimize product loss, pipe line and terminal facilities must be adequately designed, good operating methods and techniques employed, and personnel properly trained and encouraged to cooperatively practice essential conservation measures.

1953 Losses $14,000,000

Products pipe line industry total loss figures, which include both pipe line and terminal losses, are not available from any known source, but it has been estimated, based on 568,155,000 bbl delivered from product pipe lines during 1953, that the total loss figure at an average product price of $5 per barrel would amount to $14,200,000. The industry pipe line loss, which does not include terminal loss, for 1952 was 0.33 per cent and for 1953 was 0.30 per cent.* The industry should be able to reduce these losses by providing proper facilities, utilizing good operating methods, and adequately training personnel. The problem is general, and it can readily be seen why all pipe line companies are constantly striving to improve operating practices that tend to reduce this economic loss.

New pipe line systems, lines, and equipment replacing older facilities, are being designed to minimize the industry loss; however, there are still in use many older lines with relatively high leak rates and terminal tankage without vapor protection systems that materially contribute to the total loss picture. Further, it must be recognized that the rapid year-by-year growth of product movement through pipe lines will increase the total annual loss in barrels per year attributable to this phase of the oil industry's operations. This fact has a compensating effect that tends to offset any reduction of loss in barrels per year attained through the industry's efforts to improve efficiency in transportation facilities.

In most instances, product movement through pipe lines is a conversion from one method of transportation to another one that is more efficient. Thus, by utilizing modern, efficient design, and converting to pipe line movement, the total petroleum industry loss in barrels per year occasioned by transportation should be reduced.

The loss, as a per cent of total industry pipe line movement, should decrease currently for several reasons:

1. **Use of a greater proportion of new, modernly designed facilities utilizing the latest developments.**
2. **Replacement of older facilities with modern facilities.**
3. **Continued improvement of older facilities that are to be used and not replaced.**
4. **Conversion to pipe lines as a method of transportation.**
5. **Improved operating methods and techniques.**
6. **Better trained cooperative employees.**

Design Features, Construction Precautions and Initial Operations

In order to operate with a minimum product loss, the design of a product pipe line system must incorporate the basic principles essential to accomplish this objective. In addition, certain precautions must be carefully observed during construction and at the time facilities are placed in operation. Some of these principles considered essential for a product pipe line are set forth as follows:

1. **Select location of the line** where necessary and possible so that the depth of covering will be adequate to avoid loss occasioned by damage with plows, rooters, land leveling, and road grading equipment. An adequately covered line is also less accessible for tapping for purposes of theft.

2. **Provide as perfect a seal as possible** around the pipe line by coating and wrapping, using good quality coating materials. To insure best conditions, inspect the coating with a "holiday" detector and repair holidays before the line is lowered into the ditch.

3. **Be certain that pipe laid under water** has more than normal wall thickness as an additional corrosion safety factor.

4. **Provide main line block valves** at frequent intervals to minimize product loss in case of leaks, to facilitate pressure testing of the line, and to facilitate maintenance and repairs. Main line block valves are normally placed on both sides of a large river.

5. **Provide a housing around main**

*Bureau of Mines Monthly Petroleum Statement.

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line block valves that can be locked with a company padlock. Such an installation will prevent unauthorized persons from having access and still provide a simple means to permit routine inspection of valves.

6. **Install adequate cathodic protection** on the pipe line to protect against external corrosion. To be most effective, this should be done not later than the year following completion of line construction.

7. **Provide facilities either to inject** a satisfactory inhibitor to mitigate internal corrosion of the pipe line or a dehydration plant to dehydrate products before entering the main line.

8. **Provide positive displacement meters** that measure input to pipe line and output from pipe line.

9. **Air test the new pipe line** before introduction of product into the line to make sure all welding has been completed and nothing has been left disconnected.

10. **As soon as the new pipe line is filled with product,** shut down and test the line under a pressure that provides a minimum of 200-300 psi above the expected minimum operating pressure at the highest point on the line, but which does not exceed the maximum designed operating pressure at the lowest point on the line.

This is important because a line will pass a satisfactory test under 100-125 psi air pressure and may leak under normal operating pressures in case of failure caused by imperfections in pipe rolling or welding that were overlooked by inspectors.

Closed System Design

The lines and facilities constructed around a pumping station should also approach a closed system or provide a means to recover maximum amount of products removed or escaping from the system in any manner. Some of the principles involved are as follows:

1. **Provide mechanical seals on pumps** and a drain system from stuffing boxes to a sump where any leakage can be collected and returned to the system.

2. **Consider installation of in-line** or stuffing boxless pumps at intermediate station locations where only moderate increases in pressure and capacities not exceeding current design of this type pump are required, as this eliminates the packing loss problem.

3. **An adequate drain system** from equipment to a sump should be provided so that facilities can be drained for repair and the product returned to the system.

D. L. Rankin

E. H. Baird

D. L. "Dud" Rankin, manager of Wyco Pipe Line Company, is a native of Colorado. He was graduated from the Colorado School of Mines with the degree of petroleum engineer in 1923 and in the same year joined Standard Oil Company of Indiana at the Casper refinery. He became a supervisor in 1928. At the beginning of World War II he was transferred to Indiana's Whiting refinery where he was in charge of pressure stilling operations, which included the manufacture of Toluene, used as a base for T.N.T. In 1946, he became assistant manager of Standard Oil of Indiana's products pipe line department at Chicago, Illinois, and manager in 1948. In 1951, he transferred to his present position with Wyco at Denver, Colorado.

Earl H. Baird, chief dispatcher for Wyco Pipe Line Company, has had a number of years experience in the operation of crude oil and products pipe lines and terminals. He began in the oil industry in 1934 with Stanolind Pipe Line Company (now Service Pipe Line Company) as a laborer in the maintenance crew. He transferred to Standard Oil of Indiana in 1939, and in 1941 assumed charge of dispatching Indiana's products pipe lines. In 1947 he transferred to and assumed his present position stationed at Denver, Colorado.

4. **Adequate safety controls** should be provided so that pressure on the line above the safe limit cannot be exceeded for any reason. Thus, avoid a ruptured line with its attendant loss.

Terminals

At terminals, the continuance of a closed system is very essential, and some of the principles involved are as follows:

1. **Provide a vapor conservation system** of tankage for volatile products. Floating roof tanks or vapor lifter tank systems are both acceptable.

2. **Paint tankage** with a good quality of white paint to enjoy an installation with a minimum evaporation loss.

3. **Use of in-line or stuffing boxless loading pumps** located at each tank will almost completely eliminate packing loss problem.

4. **Install an adequate drain system** to a sump from all necessary facilities, but always from tank car and truck loading docks. Blending of the recovery products definitely reduces overall loss.

5. **Provide automatic set-stop meters for loading all trucks.** Many terminals load as high as 90 per cent of the products into trucks. Set-stop meters, given proper care, reduce the number and amount of spills occasioned by over-loading; are a more accurate measure than markers installed on truck compartments, which become lost, changed, bent, etc.; and permit a more efficient use of the loader's time.

6. **Provide a reliable,** good quality, easily serviced swing joint equipped with a long, light-weight, non-sparking loading spout that will extend to the bottoms of truck compartment or tank car. Such equipment will approach benefits obtained from bottom loading. The use of bottom loading by the industry is retarded because of the cost of changing trucks in service and complications encountered by transport carriers.

7. **Provide adequate fire protection equipment.** Fires extinguished in the incipient stage will prevent large losses. Make certain employees can operate the equipment and have confidence in it.

8. **Provide adequate, practical locking and sealing devices** at all points where products can be removed after once entering the system. Such protective equipment should be installed at stations, along the line, and at terminals. In addition to prevention of loss, anti-theft protection is a program cooperatively carried out with the Tax Evasion Committee. It also is a protection for company employees and is generally recognized by them as such.

9. **When air testing lines inside station** or terminal grounds prior to starting up, in order to avoid damage, do not permit air used in testing to pass through any displacement meters.

10. **Make certain, as the pipe line is receiving the initial product fill,** that air displaced from the pipe line is not permitted to pass through any displacement meters. Also, be certain the initial flow of product by-passes displacement meters until the stream is clear and free from dirt and construction debris carried along with initial product.

These principles set forth obviously do not include all those acceptable to the industry but do serve to stimulate thinking along the lines of major requirements for minimizing product loss.

Causes of Product Losses

It is important to know something about what causes product losses if

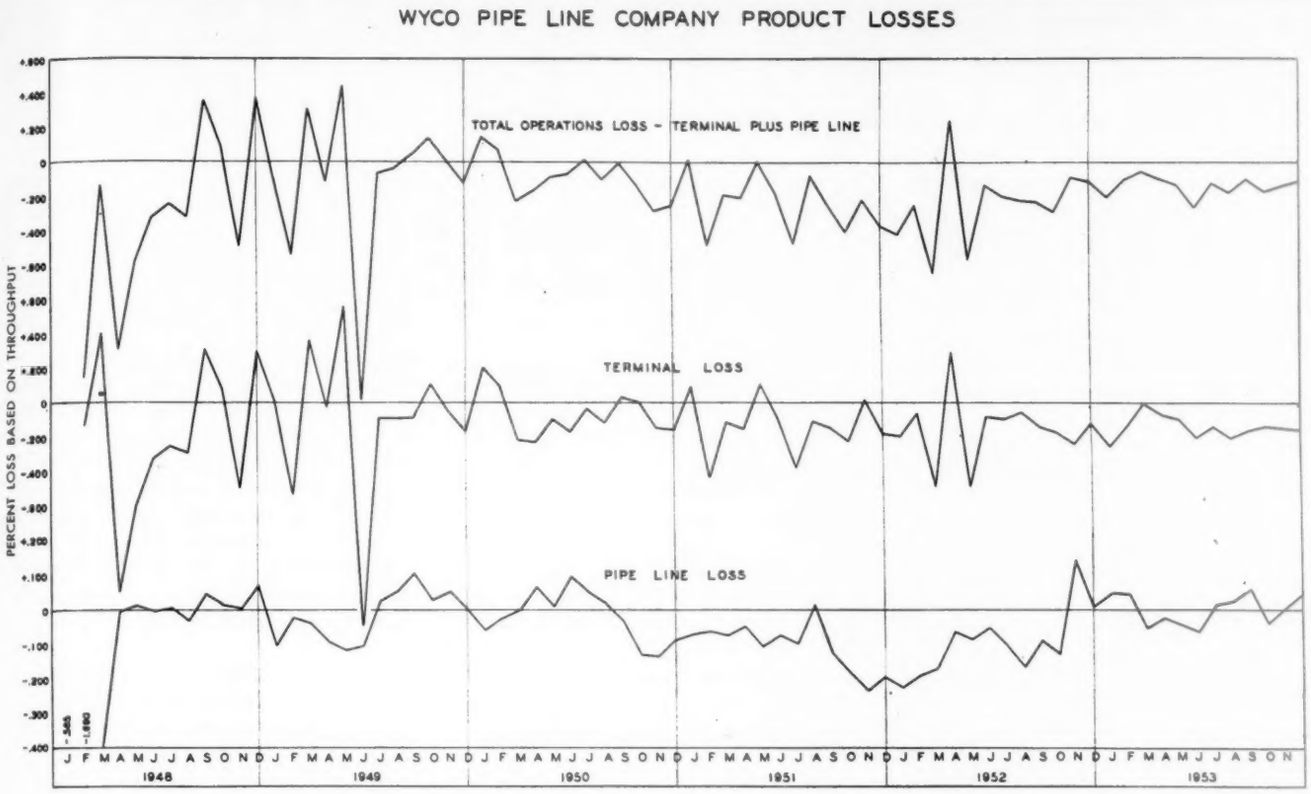
WYCO PIPE LINE COMPANY PRODUCT LOSSES
TOTAL OPERATIONS LOSS - TERMINAL PLUS PIPE LINE
TERMINAL LOSS
PIPE LINE LOSS
PERCENT LOSS BASED ON THROUGHPUT
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N
1948
1949
1950
1951
1952
1953

FIG. 1. Product losses by Wyco Pipe Line Company during six year period of study.

one is to properly consider this problem and obtain the most effective results with facilities provided, or, if designing a new system, to plan for best results.

There are two types of loss that are equally important in the operation of a pipe line. They are actual physical loss of product when product lost cannot be recovered, and apparent or fictitious loss of product caused by inaccurate methods of measurement resulting in accounting losses. In the latter case one company or one company department gains volume at the expense of another.

Some of the reasons for **physical loss** of products are listed below:

1. Leaks in trunk pipe line occurring from external corrosion (rarely from internal corrosion); rupture of line from excessive pressure or floods; damage from farming, land leveling, road grading or construction equipment; leaks at flange joints; leaks from packing glands; or, from theft.

2. Leaks in terminal or station piping usually caused by leaking joints or corroded lines.

3. Leaks from valve packing glands.

4. Leaks from pump packing glands.

5. Leaks in tank bottoms, usually where it cannot be observed. Often corrected by carrying a small water bottom in the tank.

6. Product evaporation losses:
   a. While filling tanks,
   b. While standing in storage,
   c. While emptying tank—evaporation from wetted surface,
   d. While operating at a level below which the floating roof rests on the legs.

7. Leaking swing joints and loading spouts at truck loading docks and tank car loading racks.

8. Spills occasioned by overloading trucks or tank cars.

9. Spills occasioned by opening equipment for repairs.

10. Evaporation of volatile products during loading of transport trucks or tank cars.

11. Losses occasioned by fire.

12. Losses occasioned by theft.

Apparent Losses

Some of the reasons for **apparent or accounting loss of products are:**

1. Inaccurate measurements when loading products into truck compartments. Loading to markers in truck compartments where markers are bent, missing, or changed can be inaccurate. The use of accurate set stop meters will eliminate this problem.

2. Inaccurate measuring equipment that permits errors to occur in the measurement of either input or output volumes, or both.

3. Loading tank cars over or under shell full.

4. Failure to adjust meter readings by accurate meter factors.

5. Failure to correct all volumes to 60 F basis.

6. Inaccurate inventory gages including inaccurate water bottoms gages and inaccurate tank temperatures.

Protective Measures

When one has a knowledge of what causes losses, protective measures may be undertaken. These would consist of installation of conservation equipment where economically justifiable, maintenance of measuring equipment in good operating condition at all times, establishment of sound operating procedures, training of personnel to observe leaks and promptly correct same, and, also, to operate efficiently. In order to attain maximum efficiency, a planned follow-up program by the supervisor is essential to ascertain that employees properly carry out instructions. Most of the sources of losses as discussed occur at pumping stations or terminals, and, should any occur, usually are most easily detected. Therefore, the detection of leaks in the main

pipe line, that traverses many types of terrain and is not constantly under surveillance, is most important.

How to Detect Main Line Leaks

There should be neither loss nor gain in a pipe line system operating with positive displacement input and output meters, provided measuring equipment is properly calibrated and properly used. A good hourly line balance check of input versus output volumes is essential in detecting leaks in a pipe line.

The following abnormal conditions could indicate a leak:

1. A sudden decrease below normal operating pressure at any location along the pipe line.

2. A decrease in pressure and increase in volume throughput at a pumping station, as observed on recording pressure gauge and on recording rate of flow meter.

3. Constant pressure and increase in volume throughput at a pumping station indicates a leak between meters and pumps.

4. Consistent loss between input meters at origin (station) and output meters at destinations (terminals) as determined by hourly line balance check.

Normal Precautions

Normal fluctuations as recorded on the dispatcher's log sheet often reflect some of the above characteristics of a leak and some precautions requiring checking before determining a leak condition exists are:

1. Shortages in hourly check can occur because of compressibility of products, i.e., when gasolines are used to force heavier gravity distillates out of the system.

2. Shortages or overages in hourly check can occur by increasing or decreasing the rate of flow.

3. Shortages or overages in hourly check can occur by changes in temperature of product in the pipe line.

4. Shortages or overages in hourly check can occur by changes in temperature of product delivered to origin meters. Usually a result of changing tanks at refinery by shipper or changing tenders.

5. Shortages can occur in hourly check because of failure of meter to function properly or suddenly register less barrels. This can be resolved by changing meters.

6. A shortage in the theoretical throughput accompanied by a drop in pressure at some location could occur should a pump become airbound.

Operating personnel must learn to differentiate between normal operating variations and those indicating a leak in order to take proper action when necessary.

When operations indicate that a leak in the main line might exist, the line should be promptly shut down and a pressure test made to detect and correct such a condition.

When leaks occur and losses result, a sound basis for evaluating such information is essential. Therefore, formulas for calculating pipe line losses, terminal losses, and total operating losses are included.

Pipe Line Loss. Based on throughput of batches completed during month.

Let:

BO_1, BO_2, BO_3 = Volume of batches metered at origin point, adjusted by meter factor, and corrected to 60 F.

BT_1, BT_2, BT_3 = Volume of batches completed during month, metered at terminals, adjusted by meter factor, corrected to 60 F, and adjustments made for heads and tails.

SO = Volume of sum of all completed batches metered at origin.

ST = Volume of sum of all completed batches metered at terminals.

P_L = Pipe Line Loss in barrels at 60 F.

Then:

$$SO = BO_1 + BO_2 + BO_3 \text{ etc.}$$
$$ST = BT_1 + BT_2 + BT_3 \text{ etc.}$$
$$P_L = SO - ST$$
$$\%P_L = \frac{100(SO - ST)}{SO}$$

This is an accurate method for determining pipe line loss and does not involve such variables as volume of line fill, volume of various products composing the line fill, temperature of product in the line, and temperature corrections — all of which involve certain assumptions which cannot be considered accurate. As a matter of information, the difference of % pipe line loss when based on throughput (SO) as against that based on terminal receipts (R_T) is approximately 0.001 per cent over a six-year period of operation.

Terminal Loss. The normal formula is used in determining a terminal loss based on terminal receipts.

Let:

I_F = Actual gaged inventory at first of period in barrels at 60 F.

R_T = Receipts into terminal in barrels at 60 F.

S_T = Shipments from terminal in barrels at 60 F.

I_E = Calculated inventory at end of period in barrels at 60 F.

I_A = Actual gaged inventory at end of period in barrels at 60 F.

T_L = Terminal loss in barrels at 60 F.

Then

$$I_E = I_F + R_T - S_T$$
$$T_L = I_E - I_A$$
$$\%T_L = \frac{100(I_E - I_A)}{R_T}$$

Total Operating Loss. Based on terminal receipts. Total loss would be calculated as follows:

O_L = Total operating loss in barrels at 60 F.

$$O_L = T_L + P_L$$
$$\%O_L = \frac{100(T_L + P_L)}{R_T}$$

Wyco Pipe Line Company losses are based on the preceding formulas and cover the six-year period since this pipe line started operation in 1948. Losses shown are pipe line loss, terminal loss, and total operating loss (pipe line plus terminal). Fig. 1 graphically shows these losses each month as a per cent of terminal receipts.

Table 1 summarizes these loss percentages. Losses are shown as recorded in the accounting records and as adjusted for unusual and known situations.

Part 2 of this article, which will appear in the June issue of this magazine, will discuss in detail Wyco Pipe Line Company's product losses and what was done to attain low loss record. ★

TABLE 1. Wyco Pipe Line Company product losses.

Year	Average actual annual loss %			Average adjusted annual loss %		
	Pipe line	Terminal	Total	Pipe line	Terminal	Total
1948	−0.168	−0.196	−0.370	−0.011*	−0.102†	−0.114
1949	−0.011	−0.104	−0.103	−0.001	−0.095†	−0.096
1950	−0.023	−0.070	−0.093	−0.023	−0.070	−0.093
1951	−0.101	−0.137	−0.234	−0.101	−0.137	−0.234
1952	−0.094	−0.147	−0.242	−0.094	−0.147	−0.242
1953	+0.002	−0.141	−0.141	+0.002	−0.141	−0.141

*Loss after adjusting for 5000 bbl leak occurring first months of operation.

†Loss after adjusting for terminal-line and working inventory which occurred as new lines and new tanks were filled with products when first placed in operation. These unavailable products were considered as loss in accounting procedure and were: For 1948—2869 bbl, and for 1949—319 bbl.

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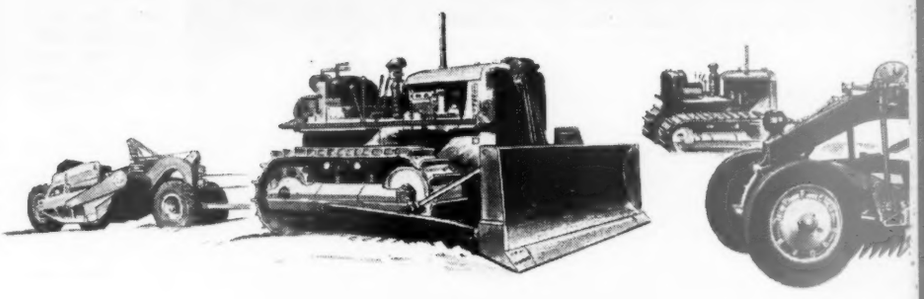

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ECONOMICS OF CATHODIC PROTECTION

Bare or coated, lines can be saved from costly leaks by applying cathodic protection; pay-out in short time makes use economically sound

WAYNE A. JOHNSON

CATHODIC protection is sometimes hard to sell due to some false ideas surrounding its use. Too often is heard the expression — "It's too far gone to do any good!"

It is precisely true that the application of cathodic protection to an existing buried pipe line or flow line (or storage tank bottom) will not replace the corroded metal; however, it is also true that if cathodic protection is properly (and completely) applied to such structures, corrosion, i.e., electrolysis, will not continue to occur. Old lines or new, bare or coated, it makes no difference as to the age or the condition of the line for cathodic protection will "pay-out," and usually in a short space of time.

Actual cost of any particular item or installation is ordinarily the important consideration in any line of business. If a particular investment can yield a profit over a specific period of time, then the investment is usually warranted. There are, however, times when investments should be made even when there is no apparent "pay-out." This is when protective equipment is required to provide safety to life and limb. Even such investments as these usually prove economically sound as "lost time" from accidents to personnel, and subsequent medical expense, is costly and usually better avoided.

Leaks Costing More and More

The dollar and cents costs of oil and gas leaks are constantly increasing. Steel continues to rise in price as does the total cost of laying a pipe line. Labor costs of maintenance have not taken a downward swing, nor are they apt to for quite some time; increased agricultural expansion has placed many additional thousands of square miles of land under cultivation, thereby making property damage more costly. Towns and cities continue to grow, often building right over existing lines. Oil and gas leaks in populated areas cannot be tolerated, as lives cannot be calculated money-wise, except by the insurance companies.

Aside from the above considerations many lines have tight delivery schedules where failure to provide continued trouble-free delivery of gas or oil can cause a shut-down of a refining plant, or a city gas distribution system! Public relations are usually calculated in dollars and cents, and failure of a gas line in the middle of winter has made more than one customer resent a gas company's request to the city council for a rate increase.

The Author

Wayne A. Johnson is the owner of Corrosion Rectifying Company of Houston, Texas, specializing in designing and installing cathodic protection systems for pipe lines and refineries. He was previously with The Texas Pipe Line Company and later with Cathodic Protection Service at Houston, as a senior corrosion engineer. A graduate of Texas A & I College, Kingsville, Texas, he is an overseas veteran of World War II, having served with both the Seabees and the U. S. Navy.

Protecting Bare Lines

Cathodic protection of a bare (uncoated) line, as a general thing, requires a more extensive application of cathodic protection than does a coated line. This is not always true, for sometimes as much as 90 per cent of the total length of an uncoated line can be protected against corrosion by applying protection on as little as 10 per cent or 15 per cent of the total length. This is done by protecting the "hot-spots" or corrosive sections, and disregarding the sections that lie in non-corrosive or only slightly corrosive soils.

A thorough soil resistivity or surface-potential type survey is required to isolate the corrosive from the non-corrosive sections. Such a survey should not be done haphazardly. Frequently, knowing the coating specifications of a coated line, and the average soil conditions surrounding the line, a fairly accurate estimate of the cathodic protection requirements can be made. Certain field information, however, is required to design either a rectifier type or magnesium anode type installation.

Any attempt to completely design a protective system, including selecting the advantageous location for planned rectifier or magnesium anode units, without certain specific field engineering data can result in a poorly designed system that might cost twice what it should and provide considerably less than the desired level of protection. There is usually little economic advantage to such a crude approach.

Records Valuable

The best way to compare the savings to be accrued from the application of cathodic protection is to keep a record of the corrosion leaks as they occur, including their costs. Basic cost of a corrosion leak should be established from the following information:

(1) Actual cost of repair (labor and materials)
(2) Cost of lost products (oil, gas etc.)
(3) Property damage.

Some leaks may cost as little as $10; others may run into thousands of dollars. If a precise record of leaks is kept, it will be noted that in most cases the frequency increases geometrically with each subsequent year. Thus, if two leaks are repaired one year, then four may be expected to occur the next, then eight, then sixteen, etc. Each year the rate will usually double the previous year's total. Naturally this is not always true, but it occurs enough so that it is far more fact than fiction.

Typical Line Study

These figures are best emphasized by studying a typical pipe line. The one we have chosen is a 4½-in. O.D. oil line, five miles in length, which was laid bare in South Texas in 1946. No corrosion leaks were observed on this line until 1949, during which year one leak occurred. Two leaks were repaired in 1950, five in 1951, ten in 1952, and eight had been located up to July 1953, at which time a cathodic protection

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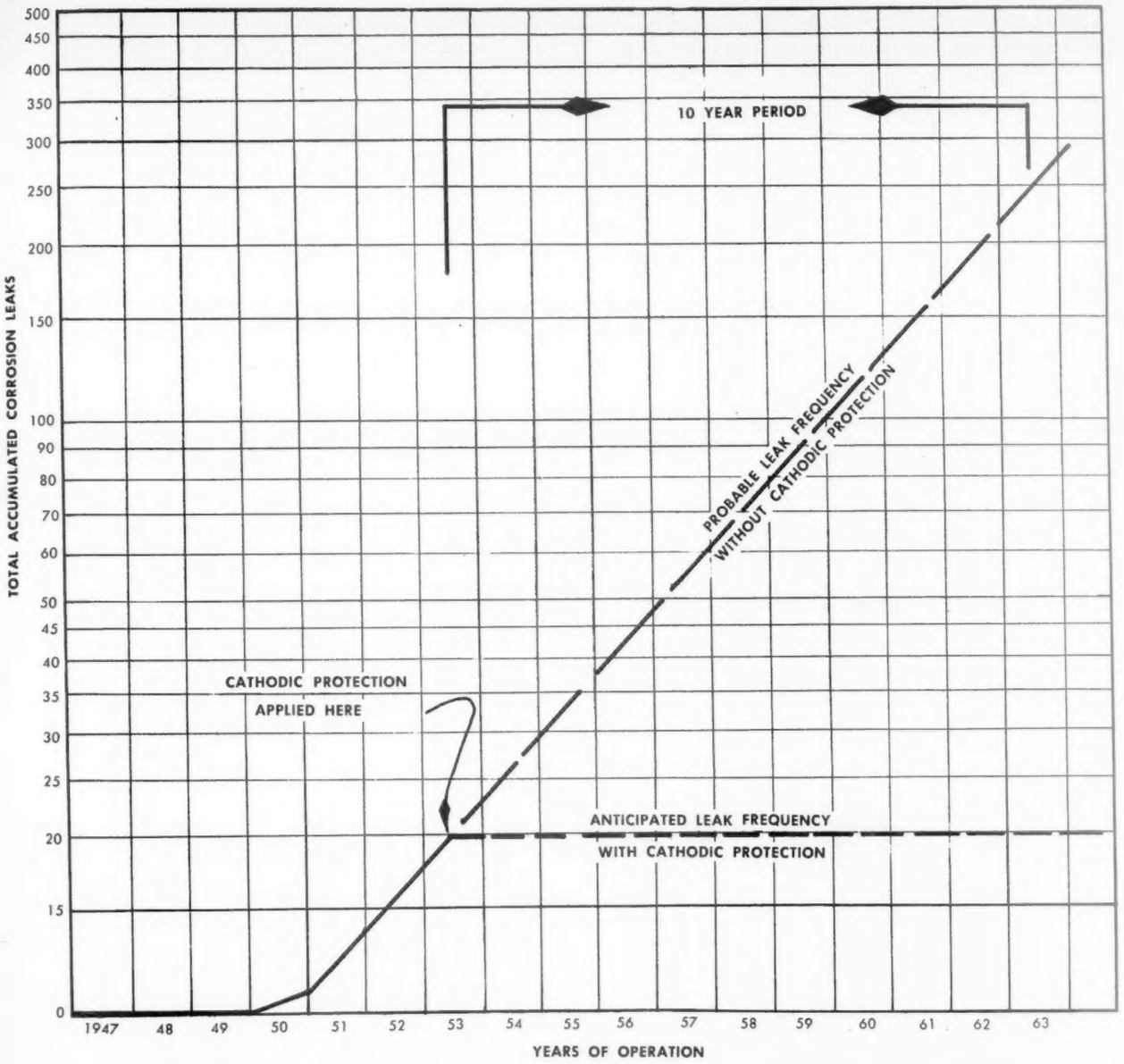

Semi-graph log, with *Years* plotted against *Total Accumulated Leaks*, shows frequency rate of leaks occuring prior to application of cathodic protection, frequency after application, and probable frequency if line had been left unprotected. Cathodic protection will hold frequency to low level, while leaks in bare line will continue nearly on a geometric progression basis.

rectifier was installed on the line. No leaks have since occurred.

Reference to the semi-log graph, *Years* versus *Total Accumulated Leaks*, shows that a "frequency" rate was being established which if allowed to continue would have resulted in a total of approximately 250 corrosion leaks in the ten years for 1953 to 1963. Cathodic protection in the form of a rectifier unit was installed in July 1953.* The dotted line indicates that no further leaks have occurred since, nor are anticipated. Experience bears out the correctness of this conclusion.

Leaks vs. Protection

Let's look at the cost of the leaks as compared to the cost of cathodic protection and see in dollars and cents exactly what this particular company can expect to "pocket."

(1) Cost of repair (200 additional leaks @ $100 ea)	$20,000
(2) Lost products (10 bbl/leak × 200 × $2.75)	5,500
(3) Property damage (200 × $20.00 av.)	4,000
Total cost of 200 leaks	$29,500
Cost of cathodic protection installation (incl. survey, design, engr.) $3495	
Electric power cost for rectifier unit (10 yr @ approx. $0.0175/KWH) 3250	
	6,745
Ten year savings is	$22,755

Thus, it is estimated that $22,755 will be saved in the operation of this line in a 10 year period. This does not take into consideration the fact that the line will remain in "as-good-as-new" condition and will therefore have considerably more value should it ever be sold. The savings amounts to about $190 per month over a 10 year period. As it cost $36,000 to lay this line in 1946 (including pipe, labor, right-of-way, etc.) it may be seen that the savings over a 10 year period represent about 63 per cent of the capital investment! It is certainly worth considering.

Conclusions

Naturally the cost of leaks will vary on different pipe lines, as will the cost of cathodic protection. On the basis of savings involved in our case, however, total cost of cathodic protection for 10 years is "paid out" in about three years.

A high percentage of the pipe lines and flow lines now corroding in the ground could be economically protected. A study of the corrosion leak costs of any specific line, as compared to the cost of cathodically protecting the line, will indicate if it will prove economical to apply protection.* * *

*Corrosion survey indicated need for "complete" cathodic protection application rather than "hot-spot" protection.

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XUM

First of a Series

Microwave System Design

W. E. SUTTER

Introduction

A great deal of information concerning the technical aspects of microwave transmission and the necessary equipment has already been published. Little, however, has been written about the practical side of designing and installing the overall system. With this thought in mind, the following series of articles presents an accumulation of valuable information on all phases of microwave aimed at those who are interested in the operation of the system rather than the mathmatics of the medium. These articles will provide the reader with the basic information on microwave and the various associated subjects that must be considered when planning an integrated communication system. Part 2 of this series will appear in the June issue of the Petroleum Engineer.

ALTHOUGH it is frequently referred to as a new medium, microwave is just as old as any other type of radio frequency transmission. Maxwell's "Wave Equations", published about 100 years ago, actually form the basis of all theory on electromagnetic wave propagation. During the intervening century, such famous men as Hertz and Marconi have conducted experiments on the application of these formulae. Many of these experiments were in the frequency range that is now called microwave but at the time no commercial possibilities for these wave lengths was uncovered. In fact, they were considered so useless comcercially that the entire spectrum above the standard broadcast frequencies was given to the "ham" operators.

Frequencies allotted to these amateur operators were gradually decreased during the 1930's, as world wide experimentation began to unearth commercial possibilities for these higher frequencies. Microwaves, however, were still considered curiosities as the clouds of war began to gather in Europe and the Far East.

Microwaves came into their own during the tremendous war time radar research program. Radar development required narrow beams of energy in order to accurately determine distance, altitude, and azimuth of the reflecting objects. At first, the work began in the 150 mc region and, as tube and circuit development continued, it became apparent that higher frequencies were required for accuracy in radar control. So, the radio frontier was gradually pushed upward, and at the end of the war, laboratories throughout the world were full of experienced men whose efforts would shortly make available commercial equipment operating in frequencies from 150 mc up to the 10,000 mc region. Only the frequencies above 900 mc are now referred to as microwaves. These newly available microwave frequencies increased the usable radio spectrum by more than 200 times the prewar space.

After the war, the FCC allocated the microwave spectrum to various users. The frequencies between 150 and 960 mc were given to television, aircraft, mobiles, and the government services. The space above 960 mc has been reserved for radar, microwave communications, television relaying, and experimental purposes.

The last century has been one of great scientific development. One hundred years ago, the Morse telegraph provided the first electrical communication system, and since that time, tremendous development has been made in the telegraph and telephone facilities of our country. During this same period, industry has come to rely more and more on fast, reliable communication in its daily operation.

To increase the efficiency of the present communications system, industry has long considered the use of radio for their point-to-point circuits. Before the war, however, the allotted frequency spectrum did not provide the necessary space to accommodate every industrial application. As the amount of available spectrum space increased and the mobile and fixed point-to-point equipment was made available, the communication services were greatly expanded. Early in 1948, several manufacturers had microwave equipment on the market, but it was not until late 1949 and early 1950 that the microwave boom really developed. Microwave engineers felt that they had a useful product but they lacked valuable field experience. This experience

EXCLUSIVE

The Author

W. E. Sutter is commercial microwave engineer for General Electric, an appointment he received this year. He was graduated from Rensselaer Polytechnic Institute, Troy, New York, with a bachelor of science degree in electrical engineering in 1945.

After three years as an electronic maintenance officer on a destroyer during the war, he joined General Electric as a test engineer in 1946.

He entered microwave engineering in 1947 when microwave communications was in its early stages of development. He had been sales engineer with General Electric microwave sales group since 1950, before receiving his present appointment this year.

TABLE 1. Cost breakdown for typical systems.

Number and type of stations	Length of system in miles	Number of Audio Channels 2	6	12	24	
2 Terminals	30	$42,000	$48,000	$57,000	$82,000	Total system cost
		1,400	1,600	1,900	2,700	Cost per mile
		700	270	158	114	Cost per channel mile
		250	89	48	23	Annual maintenance per channel mile
2 Terminals 1 Repeater	60	$67,000	$73,000	$82,000	$107,000	Total system cost
		1,100	1,200	1,370	1,780	Cost per mile
		560	200	114	75	Cost per channel mile
		150	54	28	17	Annual maintenance per channel mile
2 Terminals 5 Repeaters	180	$167,000	$173,000	$182,000	$207,000	Total system cost
		930	960	1,010	1,150	Cost per mile
		464	160	84	47	Cost per channel mile
		100	32	17	10	Annual maintenance per channel mile

was soon to come when the Keystone Pipe Line Company placed into operation the first private microwave system in the latter part of 1949. Many new systems in the pipeline industry were to follow, such as the 1840-mile Transcontinental Gas Pipe Line system, the 1000-mile Mid Valley Pipe Line system, the Texas Eastern, the Texas-Illinois, and many others, the total of which is estimated to have cost approximately $10,000,000.

There are many sound reasons for the general acceptance of microwave throughout the pipe line and power utility fields. Because of the nature of microwave transmission there are no major right-of-way problems. Through the years, these organizations have attempted to find communications systems that would provide them with the utmost in circuit reliability. With microwave, the preventive maintenance, which contributes so greatly to the reliability of any communication system, is concentrated at fixed positions.

Extensive damage to wire lines caused by severe storms that have swept the country during the past few years has only served to spotlight the need for communication systems that operated dependably under all weather conditions. Microwave represents an excellent solution to this dependability problem.

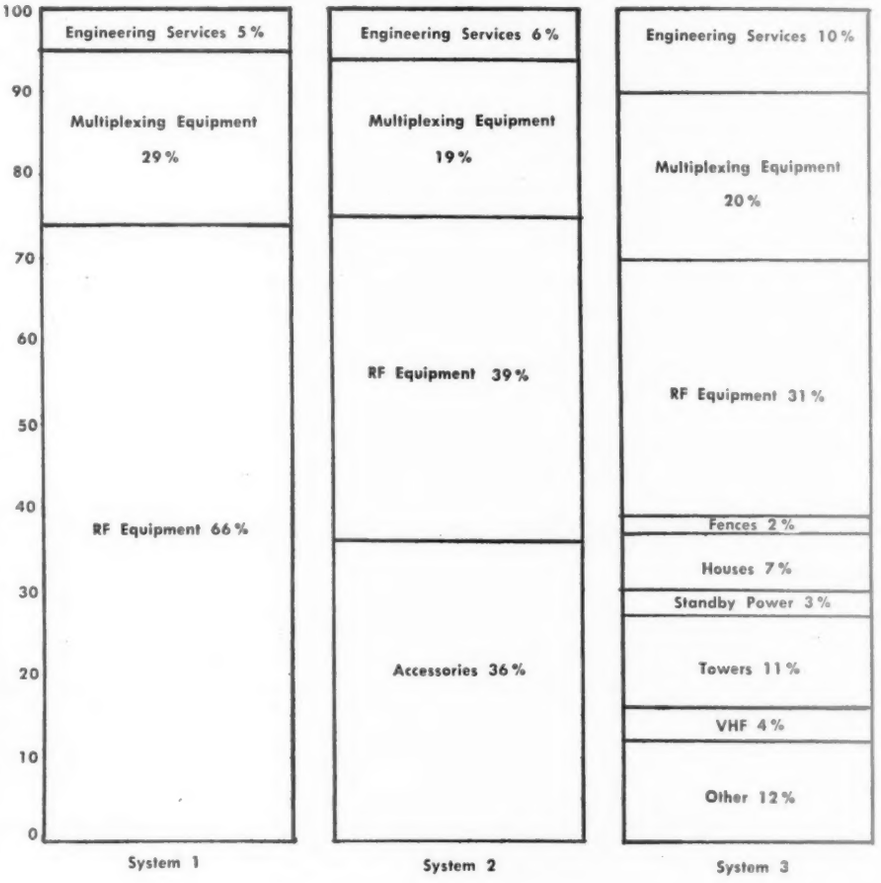
In the case of cable or other wire lines, it is sometimes necessary to include many pairs of wires in the initial installation solely for the purpose of anticipated expansion. If the anticipated expansion does not take place, these wires are idle. Microwave links, on the other hand, can build upon the basis of the actual traffic demand and can be expanded when necessary. Starting with any desired number of channels, additional voice communication channels up to a maximum of 24 can readily be added by the addition of small, compact plug-in units.

In addition to microwave's dependability characteristics, competition in the microwave field has made it possible to install an average microwave system in flat country for approximately $1000 per mile. This figure includes not only the basic radio and multiplexing equipment, but also the towers, buildings, fences, standby power equipment, and other accessory equipment utilized on most modern communication systems.

This figure compares quite favorably with the cost of modern open wire telephone installations, which vary from $1000 to $1500 per mile. Actually, these figures do not relate the entire story as additional channels may be added to the basic microwave system without significant change in the equipment cost per mile. As construction of telephone open wire lines and underground cables varies so greatly, depending upon the terrain and the local weather conditions, a brief summary of the microwave installation costs is presented for comparison with local construction costs.

Table 1 shows the system cost, cost per mile, cost per channel mile, and annual maintenance cost per channel mile for three typical microwave systems. In reviewing the information presented, it is quite obvious that mi-

TABLE 2. Percentage breakdown of system costs.



crowave becomes increasingly economical in heavy traffic systems or when the system is utilized over distances greater than 30 miles.

The many items that are integrated into the overall microwave installations will be discussed later in detail. Table 2 portrays the breakdown of initial construction costs showing the percentage invested in RF, multiplexing, towers, buildings, emergency power generators, and engineering services. System 1 shows the relative breakdown between RF and the multiplexing, disregarding all other items. Systems 2 and 3 portray a microwave system in its entirety for a public utility and a long distance pipe line respectively. The relative percentages for these installations remain almost constant.

Probably the soundest basis for comparison between microwave links, wire construction, and leased telephone circuits would be the total annual maintenance cost for each system. This cost is a function of the initial installation costs, depreciation rates, annual maintenance, repair costs, and the various other minor charges. The total annual maintenance for a typical microwave system is itemized in Table 3 and summarized for various conditions in Table 1.

The maintenance figure is based on the services of one technician, since it is generally the practice to have one maintenance man for each 200 miles of the microwave system. On an average system, this would require that the man will maintain approximately eight stations. In amortizing the costs of the system, the microwave equipment has a rapid obsolescence and therefore is amortized over a period of ten years. The buildings, towers, and other accessories, however, are amortized over a period of 20 years. Interest cost is usually 4 per cent per year and the taxes average 1 per cent.

The maintenance figures were set up on the basis of one scheduled visit per week to each station and one unanti-

TABLE 3. Typical microwave system.
2 Terminals and 5 Repeaters — 12 Channels

Initial Cost			
Land and roads	$ 5,600		
Radio and multiplexing	107,000		
Towers	35,000		
Housing	12,500		
Fences	4,000		
Standby Power	10,500		
Accessories	13,000		
Total initial cost	$187,600		
Operating Cost			
(1) Amortization			
(a) Radio equipment 10%		$10,700	
(b) Associated equipment 5%		4,030	
			$14,730
(2) Interest and Taxes			
(a) Interest (4% of 187,600/2)		3,752	
(b) Taxes (1% of 187,000)		1,876	$ 5,628
(3) Maintenance			
(a) Radio and multiplexing			
Tubes		4,500	
Replacement parts		1,000	
Labor, car and living expenses		7,000	
Commercial power		2,500	
		15,000	
(b) Emergency power supply		1,000	
(c) Buildings, structures, grounds		1,500	$17,500
Total yearly operating costs			$37,858
		37,858	
Operating cost per channel mile per year			$17.50
		12 x 180	

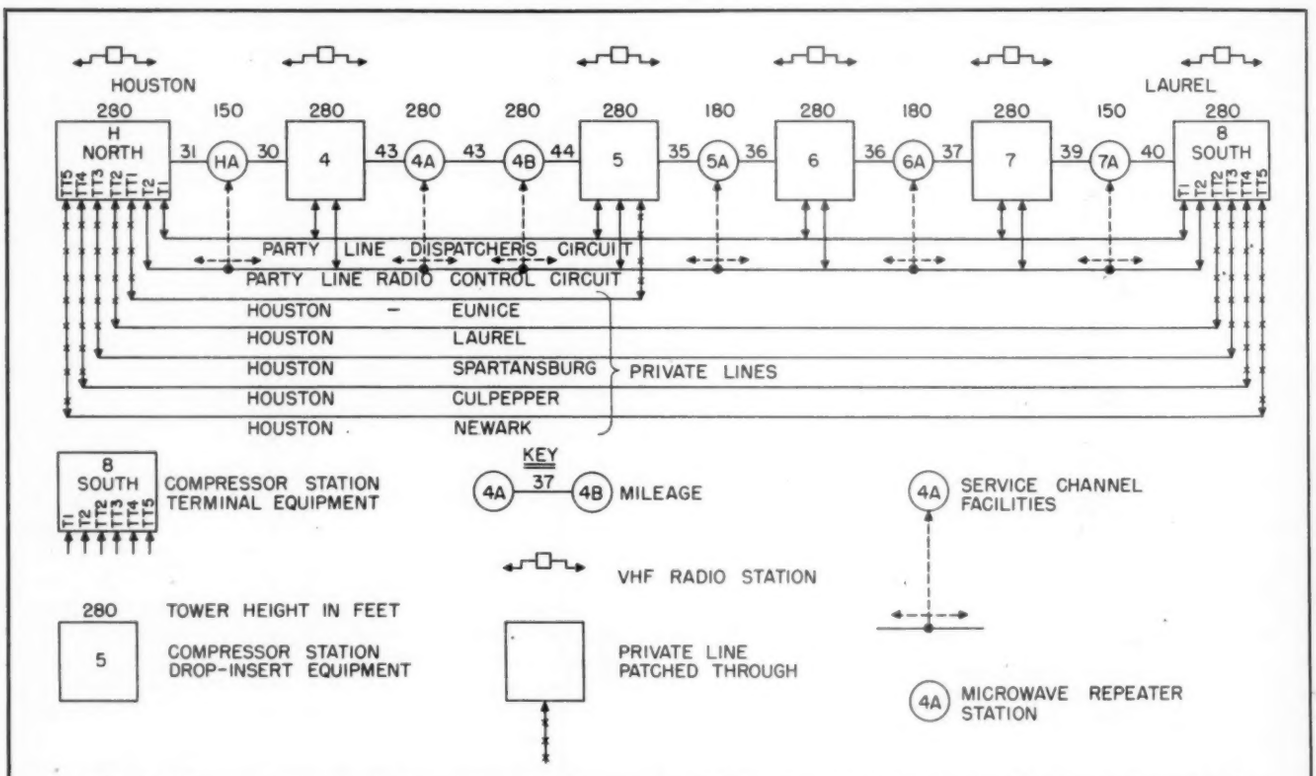

HOUSTON
LAUREL
280 150 280 280 280 280 180 280 180 280 150 280
H NORTH
31 HA 30 4 43 4A 43 4B 44 5 35 5A 36 6 36 6A 37 7 39 7A 40
8 SOUTH
T5 T4 T3 T2 T1 T1
PARTY LINE DISPATCHERS CIRCUIT
PARTY LINE RADIO CONTROL CIRCUIT
HOUSTON – EUNICE
HOUSTON LAUREL
HOUSTON SPARTANSBURG
HOUSTON CULPEPPER
HOUSTON NEWARK
PRIVATE LINES
8 SOUTH
T1 T2 T3 T4 T5
COMPRESSOR STATION TERMINAL EQUIPMENT
KEY
4A 37 4B MILEAGE
4A SERVICE CHANNEL FACILITIES
VHF RADIO STATION
280 TOWER HEIGHT IN FEET
5 COMPRESSOR STATION DROP-INSERT EQUIPMENT
PRIVATE LINE PATCHED THROUGH
4A MICROWAVE REPEATER STATION

FIG. 1. Microwave communication system for Transcontinental Gas Pipe Line Corporation, Houston to Laurel section.

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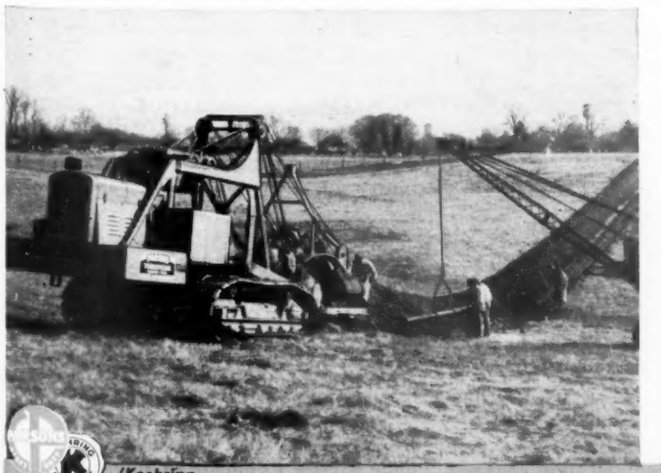

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(Koehring Subsidiary) **CHECK PARSONS FOR TRENCH WIDTHS FROM 8 TO 72 INCHES . . . DEPTHS TO 17 FEET**

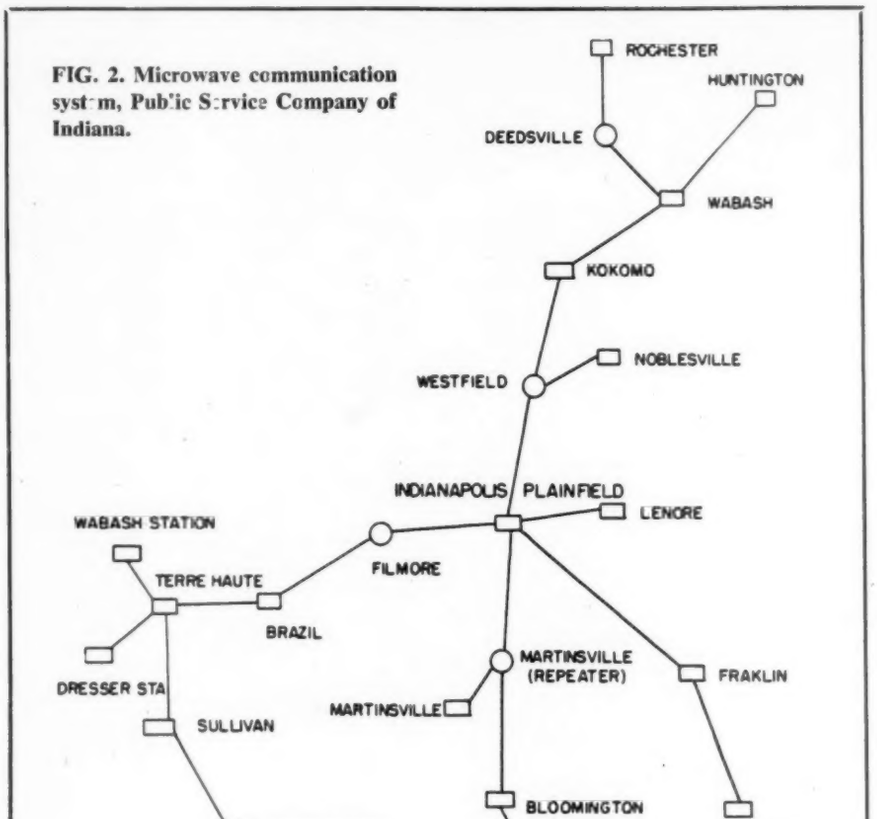

FIG. 2. Microwave communication system, Public Service Company of Indiana.

cipated service per week. The total cost covers the man's salary plus living expenses while on the road as well as the maintenance charges for his car.

The replacement cost of transmitting tubes was estimated on the basis of a complete change of these tubes twice a year. Present indications are, however, that the tubes will last longer and approach an 8000 hour mark. The receiving tube replacements of course will be much lower. As for miscellaneous spare parts, they were estimated at one per cent of the initial cost.

Tower, house, and land upkeep are based on approximately $200 per station per year. The emergency power equipment cost includes parts, gasoline, oil and general overhaul.

In accordance with the latest FCC allocations, microwave systems can be licensed for various industrial users in the following frequency bands: 890-936 mc, common carrier; 952-960 mc, operational fixed; 1590-1990 mc, operational fixed; 2110-2200 mc, operational fixed; 2500-2700 mc, operational fixed; 3700-4200 mc, common carrier; 5925-6425 mc, common carrier; 6575-6875 mc, operational fixed; 10,700-11,700 mc, common carrier; 12,200-12,700 mc, operational fixed.

All organizations that qualify in the safety and special radio services section of the FCC allocations can be licensed in the various "operational fixed" bands. At the present time, all allocations are issued on the developmental basis since the rules governing the operation of microwave systems have yet to be announced.

For services operating in the public safety, industrial, and land transportation radio services, application must be made on FCC form 400, while all other services will make application on form 401. A license must be obtained for each fixed station.

Already, many large corporations have engaged this new tool to provide a more flexible, more economical communication system. Today, about 100 microwave installations making up approximately 50,000 route miles of microwave systems are either in operation or under construction. These installations have a combined total of approximately 1800 stations, of which almost 60 per cent are now in operation. In the petroleum field, there are nearly 30 installations, of which the Transcontinental Gas Pipe Line system is the largest and probably the most publicized.

Among the 40 odd microwave installations in the power utility field, are such organizations as Bonneville Power Administration, Public Service Company of Indiana, The Tennessee Valley Authority, Philadelphia Electric Company, and The Public Service Electric and Gas Company of New Jersey.

The Transco system is an excellent example of the application of a microwave system to a long distance pipe line operation.

This system utilizes 2000-mc equipment to provide multi-channel communication from Falfurrias, Texas, to Newark, New Jersey, a total air line distance of 1840 miles. Their system consists of 59 stations with the average distance between microwave stations of 31 miles. Twenty-three of the above

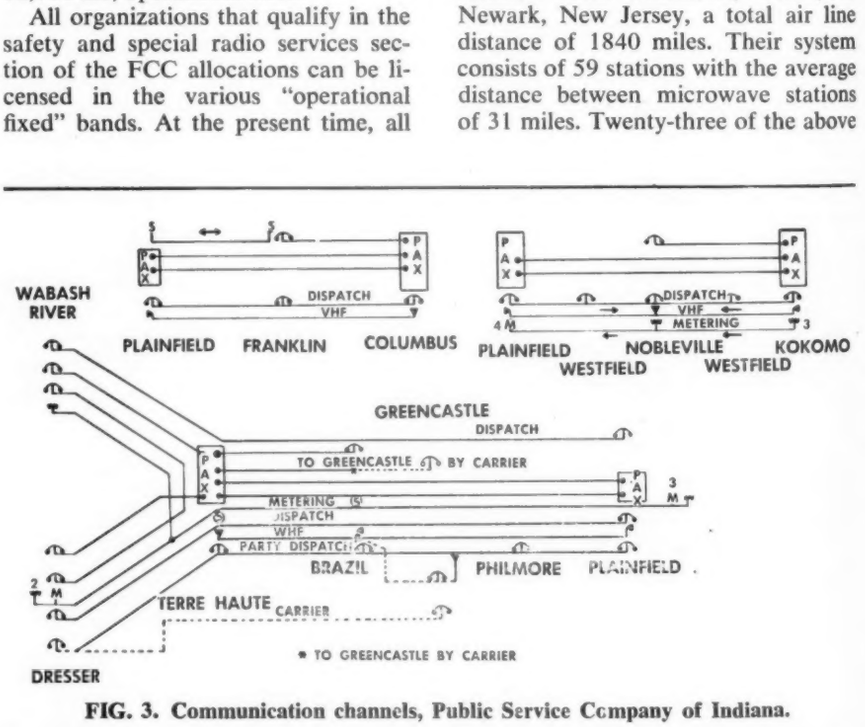

FIG. 3. Communication channels, Public Service Company of Indiana.

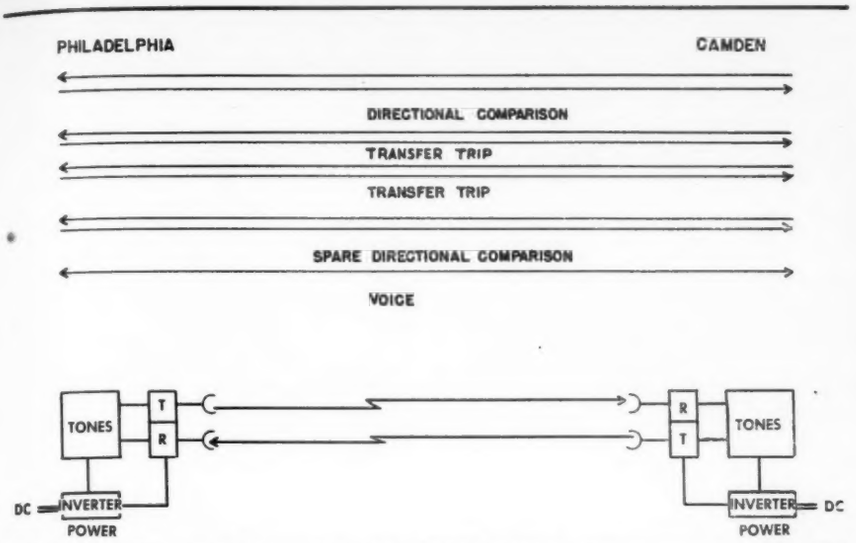

FIG. 4. Line diagram of channels used by Philadelphia Electric Company and the Public Service Electric and Gas Company of New Jersey.

stations provide audio at various offices along the route. The other stations are merely RF repeaters for receiving and retransmitting the microwave carrier.

Each station is equipped with stand-by RF equipment, which is switched into operation automatically when faults occur in the operating units, and a stand-by power generator that operates on failure of the primary power. A coded fault system is also included which reports any abnormal operation to the district maintenance headquarters. Fig. 1 shows the channel facilities provided on one section of the Transco system between Houston, Texas, and Laurel, Mississippi. As you can see, there are 12 stations involved in this section of the system. Channels are provided for party line dispatching and radio control of VHF equipment together with the private line business circuits between Houston and the various main offices along the entire system. As you will note, channel TT5, shown on this illustration is a through channel from one end of the system to the other, namely from Houston to New York.

The Public Service Company of Indiana microwave system (Fig. 2) also utilizes 2000 mc equipment to provide multi-channel communications between offices and various sub-stations in this public utility power network. Here again, each station is complete with stand-by RF which is switched into operation automatically when a fault occurs in the operating unit in order to provide the utmost in system reliability. The system (Fig. 3) provides both private voice channels, telemetering channels, and a VHF circuit for complete coverage throughout the network.

There are many installations now using 960 mc equipment. This equipment basically lends itself to the application of low channel capacity point-to-point systems. Being extremely versatile, it adapts itself to a wide variety of applications including: Voice communication channels with either code ringing or complete dialing service, protective relaying channels, supervisory channels, and telemetering channels, as well as providing economical means of broadening one's VHF horizons by utilizing it as a remote control unit for distantly located VHF base stations.

In Fig. 4 is shown a line diagram of the channels now being employed by the Philadelphia Electric Company and the Public Service Electric and Gas Company of New Jersey for relaying, transfer trip, and voice communications between the Camden substation and the Philadelphia sub-station.

As another example of the versatility of this equipment, the Acme Natural Gas Company of Butler, Pennsylvania, employs a one-way system involving two tone units to provide remote indication of two pressure readings. The state of Massachusetts has placed a VHF transmitter high on Mount Wachusett some 43 miles outside of busy downtown Boston, in order to obtain wide coverage for their VHF base station. This base station is remotely controlled by 960 mc microwave equipment from operational headquarters in downtown Boston.

Recently the Public Service of Oklahoma added 960 mc equipment to its communication system in order to connect a sub-station and their downtown Oklahoma office. The system provides one voice channel and 9 two-way channels for extending their carrier telemetering and load control circuits to their downtown lead dispatcher's office.

* * *

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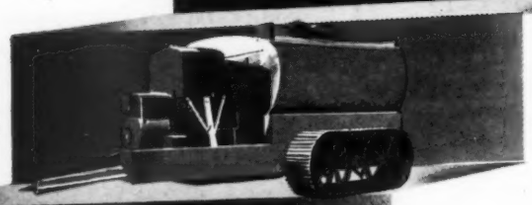

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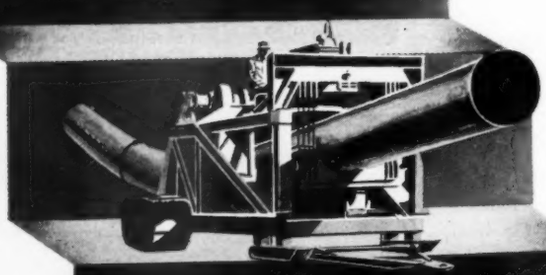
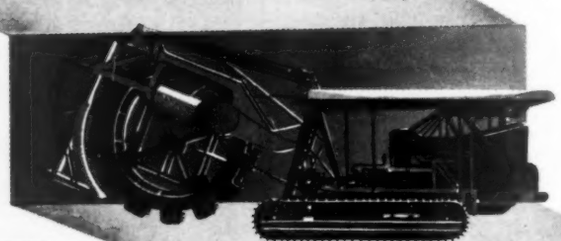


C-R-C VERTICAL BENDING MACHINE—VERTICAL BEND FOR ACCURATE MEASUREMENT FROM 10" THROUGH 36" PIPE SIZES.



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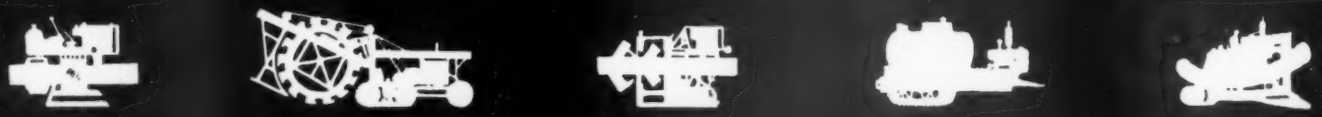

In the area through which the lines of Natural Gas Pipeline Company pass, sheet erosion like this was common . . . and a disturbing factor to men engaged in maintaining the right-of-way.

Properly applied soil conservation practices results in such right-of-way scenes as this, where crops and good will flourish, and both farmers and pipeliners reap benefits.

Soil Conservation:

P 605.51 .

A New Philosophy in Backfill Maintenance

Over a period of 23 years Natural Gas Pipeline Company has developed modern methods for tying-down the cover on its lines, promoted the best of public relations, and performed a community service

EDWARD D. WARREN

FARMING of 8000 acres of pipe line right-of-way over a spread of 1000 miles without the loss of food and fiber for an ever-increasing population is the story of right-of-way management program conducted by Natural Gas Pipeline Company of America.

Unparalled is the story of a transmission facility that serves so many at the expense of none. Consider for a moment, if you will, that one mile of vehicle right-of-way four rods wide, denies for its duration 8 acres of land — land that has forfeited its inalienable right to produce substance for man.

No such correlation need be applied to the transmission facility of the present day pipe line. The ever-increasing number of miles of line can be made a positive force for enhancing the productive capacity of right-of-way and adjacent lands.

Now follow back with me and witness through our eyes the marriage of soil conservation and the pipe line industry.

Between August 22, 1930, and August 5, 1931, the first "big inch" high pressure pipe line was constructed by the Natural Gas Pipeline Company of America. This system, some 1000 miles in length, began at a point near Amarillo, Texas, and traveled northeast to Plattsmouth, Nebraska, and then eastward to Joliet, Illinois.

The Author

Edward D. Warren is field superintendent of pipe lines for Natural Gas Pipeline Company of America.

He attended the University of Colorado and was graduated from Colorado College. Following his graduation he was employed by the Ventura Consolidated Oil Fields as an engineer and later for an extended period as an engineer for the Empire Companies. He has been connected with the Natural Gas Pipeline Company of America since it was organized. Prior to his present assignment he was division superintendent. His company headquarters are at Beatrice, Nebraska.

The original 24-in. line was composed of 40-ft joints, which were alternately welded and coupled.

Incorporated into the design of this system was the multiple line crossings of larger streams. This served as one mechanical means of fulfilling management's dedication to uninterrupted operation.

This was the first of two lines to be built; the second, a 26-in. welded line, was to see completion in the early post war years of World War II. Both were to provide natural gas for the metropolitan area of Chicago, as well as a number of cities and towns enroute — principally in Iowa and Illinois.

Straight Line Route Necessary

The right-of-way in general, by necessity, follows a straight line regardless of soils, land slope or other topographical of physiographic obstacle. In doing so, it must pass through plains, hills, streams, and rivers that are constantly being buffeted by wind, rain, flood, and all the variances contrived by nature and man.

Early in the history of the original line it became evident that management's dedication to continuous service was being jeopardized by an angry Nature thrown out of her ecological state. Large gullies were constatly forming, undermining the line and stripping the backfill, and as the earth disappeared, so did security. In many cases too, farmers by their varied farm-

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ing practices, were accelerating erosion. All to the end that the pipe line was gradually coming nearer to the surface.

A New Concept Arises

To the operating force, erosion control seemed to be the answer, but their problem was where to get the information and requisite technical guidance to bring about a stabilized right-of-way. Here was a situation that defied the customary engineering approach. Gone were the familiar factors, and in their stead arose new concepts involving soil classification, land slopes, erosion control practices, fertilizers, and many new soil management techniques.

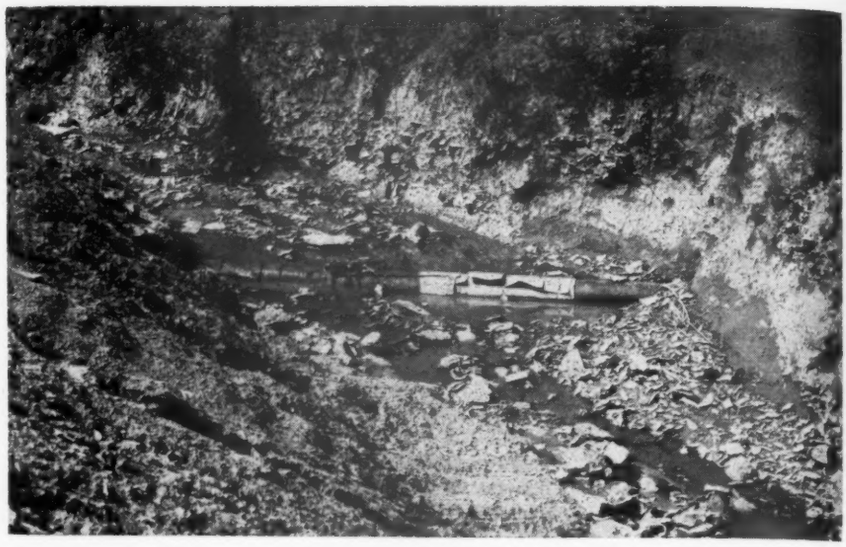
In 1931, there was no known movement to apply erosion control methods on a national or regional basis. No one in the industry comprehended that erosion control practices included contour farming, terrace construction, seeding to grasses and possible installation of structures. Therefore, such elementary practices as gully control with wire and brush check dams gave only momentary relief.

Large forces of men with shovels, trucks to haul dirt, and farmers with teams and slips, when they could be hired in the off season, were used to backfill in seasons when damage to crops would be at a minimum. How futile this was, with land being plowed up and down hill, with overgrazing denuding the vegetal cover, and over cultivation subjecting the soil to removal by every severe wind and rain!

Cooperation Required

The problems were many and perplexing. The field force not only had to acquire the indicated technical knowledge, but sorely needed the cooperation of the land owner. The farmer was not interested in company problems of maintaining a continuous flow of gas. He was, in many instances, quite hostile to the preventive work that of necessity had to be done. With many, their sole concession was the recognition of the fact that the company did have a pipe line easement across the land.

From such beginnings, a new philosophy was born — a need for common understanding and mutual assistance between land owner and company. Fortunately for both, impetus was being given to the final realization of this philosophy by Nature in the guise of the drouth and dust storms of '34 and '36. An aroused consciousness of the plight of our country was pointing to conservation as the medium possessing the intergrated arms to combat the forces of wind and water. From this was to come the spark that ultimately burned down the barriers between right-of-way and adjacent lands.



Pipe lines must pass across plains, over hills, and through streams and rivers that are constantly buffeted by wind, rain, and flood. Gully action, caused by water erosion, can cause tremendous damage, such as this exposed section of line.

Aid Came From SCS

A few books were becoming available on the techniques of erosion control and some technical assistance was appearing from various sources. Notable among these sources for information and assistance was the Soil Conservation Service. To this information and help was added many practices being developed by the pipe line field forces through their varied experiences.

In accord with the avowed principle of continuous service to the consumer, initial stabilization efforts were instigated from the market outward. Prior to 1940, emphasis had been placed on the solution of specific aggravated cases of erosion. Many of these were handled in conjunction with technical assistance from regional offices of the Soil Conservation Service.

By June 15, 1939, 26 of the 48 states had passed legislation enabling the organization of soil conservation districts, and by 1942, an occasional district had been organized in areas crossed by the pipe line right-of-way. Field personnel of the company were quick to note that in these areas where soil conservation districts had been organized, farmers and ranchers were not only willing but were becoming cooperative in conferring with pipe line field men in working out solutions to the erosion problems affecting the right-of-way.

In 1942, the Regional office of the U. S. Soil Conservation Service at Lincoln, Nebraska, was contacted by representatives of the pipe line supervisory staff. There followed from these preliminary contacts an establishment of friendly relations that resulted in subsequent meetings of field personnel from both organizations. Many of these took the form of study sessions, while others included field inspection of particular and type form problems. In this manner, an understanding was achieved of the operating mode of both parties.

In the meantime, land use capability maps were studied, and the most erodible sections were picked out. Mile-by-mile surveys were immediately started covering these marginal areas. This involved patrolling the line on foot and listing all locations requiring attention. Pipeline and Soil Conservation Service engineers then classified these points as to their urgency and assigned priorities for work.

A Plan Develops

What more natural result than an evolution outward from the confines of the right-of-way? Consider for a moment the development of terraces; terraces require outlets, outlets demand waterways, and waterways presuppose a knowledge of intended land use. Such factors with an affinity for each other, might well be expected to combine spontaneously, even without the presence of the asserted needs of both land owner and pipe line to serve as a catalyst.

Even though the ingredients were present, the mixture needed shaking. The winter of '42-'43 was used to obtain farmer cooperation and to lay out work for the ensuing year. Company field men worked with farmers, discussed with them their common problems, and enlisted the aid of local men representing the Soil Conservation Service. It was during this year that a start was made toward an integrated attack upon erosion on areas adjacent to and including the right-of-ways.

During this era, erosion control

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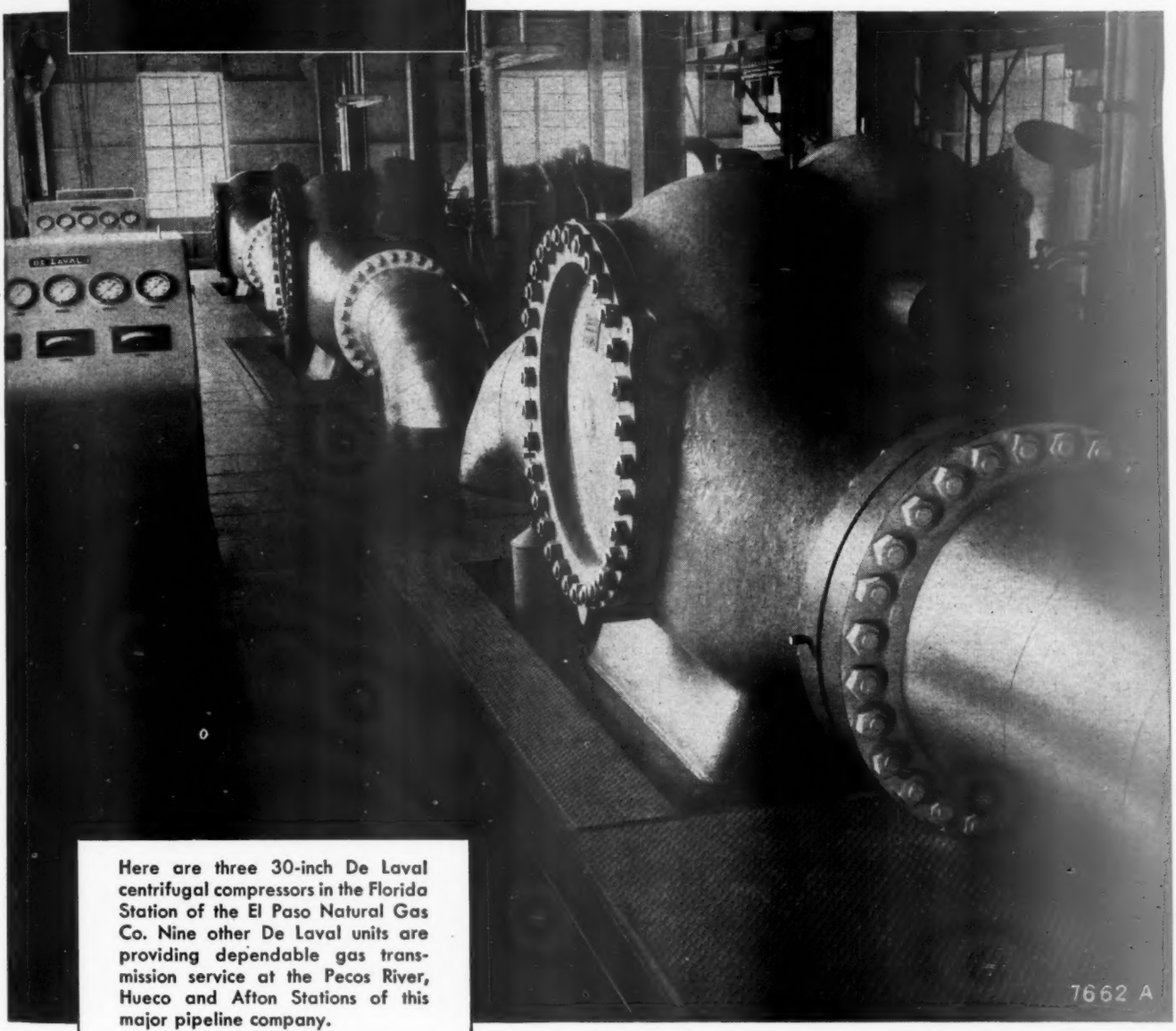

Here are three 30-inch De Laval centrifugal compressors in the Florida Station of the El Paso Natural Gas Co. Nine other De Laval units are providing dependable gas transmission service at the Pecos River, Hueco and Afton Stations of this major pipeline company.

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measures had been concentrated in Iowa, Nebraska and Northeastern Kansas. It was here, too, that soil conservation districts first appeared in the organized form. Their advent brought the necessary mechanisms to bring about a coordination of technical assistance and benefit payments to individual farmers.

This likewise broadened the approach to lands adjacent to the right-of-way. With this medium it was now possible to treat the right-of-way and surrounding land as one entity.

Pipeliners Schooled in Methods

In February, 1943, a three-day school was held in the regional office of the Soil Conservation Service, Lincoln, Nebraska. Members of the regional technical staff lectured to and discussed with company personnel practical soil conservation and erosion control. All of this made better practitioners and more enthusiastic preachers of the gospel — all the more effective because company personnel were continually gaining an appreciation for the land owners' problems.

It was at this stage that graduation occurred from the horse and buggy to the automobile. Farm type tractors were purchased by the Natural Gas Pipeline Company of America equipped with disc terracers, hydro scoops rear end blades, mowers, and every conceivable attachment for performing soil conservation work. These implements augmented the effort of crawler type dozers that were pressed into the organized attack. Under this momentum, field forces carried through the working season of 1943.

Still a second meeting was held with the Soil Conservation Service in the spring of 1944. During this conference, erosion control procedures were once again reviewed and specific problems encountered in the preceding years work were discussed. More complex techniques were offered and a more organized approach to the problem was formulated. Field men emerged from this session with a feeling of confidence born of experience and knowledge.

Working Together Pays Off

Now, pipeline personnel, too, were equipped to discuss intelligently mutual problems with the farmers on a cooperative basis. How much better than in the early days when, not infrequently, field men awoke to the fact that their best laid plans for the right-of-way had gone for naught because the land owner had other ideas!

Company terraces were now coordinated with those of the land owner and run off was controlled for the benefit of both. Required waterways were no longer destroyed with over grazing or by the encroachment of heedless tilling. Structures for stabilizing gullies were chosen not only for their retentive value but also for the water conservation needs of the particular farmer. From such arrangements sponsored by company personnel there has come the restoration of many marginal lands, and even instances of abandoned lands, to a renewed state of productivity.

"In one sense 'we had arrived,' for now common understanding and mutual assistance between land owner and company was a reality."

13 Formative Years

It is true that to arrive at this stage of development by 1944, some thirteen years had elapsed, but they were formative years with a few backward steps.

With the total acceptance of Soil Conservation as a dominant aid to be administered with a conscience for all, the Natural Gas Pipeline Company of America's backfill maintenance program during the past nine years has taken a unique twist.

By 1950, the company noted, with a great deal of satisfaction, that the entire length of its right-of-way was included in organized Soil Conservation districts. A large measure of this satisfaction was derived from the fact that company personnel had been instrumental in the instigation of activities that culminated in many district organizations.

Costs Decline, Benefits Multiply

As more farmers become interested in adopting needed practices, unit costs for preventive and remedial works declined but the aggregated benefits multiplied beyond the sum of individual efforts. From the initial efforts on the right-of-way this thing has grown — always outward. At first the company stood alone, then beside the man on whose land it crossed. Next it was his neighbor, John, who had been peering over their collective shoulders all the while. John would just happen by with a few pointed questions and a wary eye, and then slip home to put into practice what he had seen. Finally the "Johns" became identified with entire communities.

All to the end, that from the meager area encompassed by its right-of-way, the company has seen the spread of water and soil conservation practices as they have moved from effect to cause — from soil erosion to erosion control.

What has this meant to the pipe line company? Simply this — that with the good will of its neighbors, it has taken one more step in the fulfillment of its creed, "the efficient and uninterrupted supply of natural gas." * * *

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P 622

Fundamental Considerations Involved In

Design and Planning of Pipe Lines

Modern pipelining isn't a haphazard affair; from conception to operation, it involves a long series of carefully planned engineering procedures, all necessary to success

FRANK E. HANGS

WHEN a new pipe line project presents itself initially, it can be stated in very general terms: A new outlet is needed. The development from these general terms to a specific ones — capacity, line size, route, number and location of stations, horsepower, machinery, tankage and probably earnings or savings is an involved and often time consuming process.

An outline of how some phases of the general pipe line problem are defined and correlated with other, often conflicting, phases and developed to the ultimate design, is of interest and perhaps may be helpful to many people concerned with these matters.

Some primary considerations that are usually resolved by the management or directors of the firm or corporation interested in the pipe line:

(1) The reserves of crude or gas must be adequate to sustain pipe line capacity for periods of fifteen to twenty years.

(2) The potential market must indicate sufficient volume for the pipe line during its normal payout.

Some technical and engineering services may be required in determining and evaluating reserves or markets. Oftentimes a large corporation may have its own staff to compile this data; frequently outside consultants are engaged.

Economic Studies Required

Even though reserves of potential markets are adequate, economic studies are required. There must be some incentive to attract capital. There must be actual savings over existing costs of transportation. On entering a new market area, the competitive position of the crude, gas, or product transported by pipe line must be good with reference to similar products from other sources. Again there is need to review the position of competitive fuels; oil and gas with coal or oil with gas.

In brief, a successful pipe line must be in position to deliver its commodity to market so that the selling price will meet competition. A market survey is justified before large financial commitments are made.

Let us assume that the reserves are adequate, the potential market verified and the competitive position determined to be strong. In addition, some workable estimate of the initial capacity of the pipe line has been made with reasonable allowances for growth and development.

Now more specific information can be developed; a tentative route is selected from maps; a profile is required and is prepared for lines transporting liquids; several combinations of pipe sizes and station spacings are studied to determine the most economical arrangement; preliminary cost estimates are prepared for these alternate pipe sizes and operating costs estimated so that cost of transmission by pipe line can be developed; a statement of earnings is prepared; in some cases a bond retirement schedule is also worked out.

Special Procedures

At this point special procedures are followed:

In the event of a gas transmission line, which comes under the jurisdiction of the Federal Power Commission, exhibits are required for presentation at hearings before this body, which has both permissive and regulatory functions.

The proponents of the gas line are obliged to satisfy the FPC on various counts, among which are: Available and adequate reserves for a period of time, as 20 years; an assured market — customers who will enter into long term contracts; adequate financing. The proponents of the proposed line must be prepared to take the time and to have the resources to go through this procedure to obtain the necessary certificate of public convenience and necessity from the FPC.

In the case of common-carrier crude or products lines, tariffs are regulated by the Interstate Commerce Commission. The ICC does not have permissive authority in the same sense that the FPC does. Most of these lines are shipper-owned and are privately financed. A few are financed otherwise.

No attempt will be made to outline the manner or means of financing a pipe line. For the purpose of this article it will be assumed that the necessary financial backing has been already obtained. The problems of interest now are to develop the final design and to build the pipe line.

Organizing the Project

At the outset of a major project, it is highly desirable to set up a project manager and to give him the staff to handle the work. Civil, mechanical, electrical, corrosion engineers, a right-of-way section, a contract section, accountants, clerks, legal assistance, stenographers, and field personnel are required. With this organization, much confusion and loss of time due to lack of coordination will be avoided.

Once the commitment to build a line is made, the pressure is on to complete the work as soon as humanly possible. During the construction phase, money

The Author

Frank E. Hangs is chief design engineer for the C. R. C. Enginering Company, Houston. He is a mechanical engineering graduate of the University of Illinois and has been in pipe line engineering more than 20 years. He formerly worked for the Texas Pipe Line Company and Transcontinental Gas Pipe Line Corporation and as part time professor at the University of Houston. He served as petroleum officer in China (Lieutenant Colonel). Several of his articles have been published in The Petroleum Engineer.

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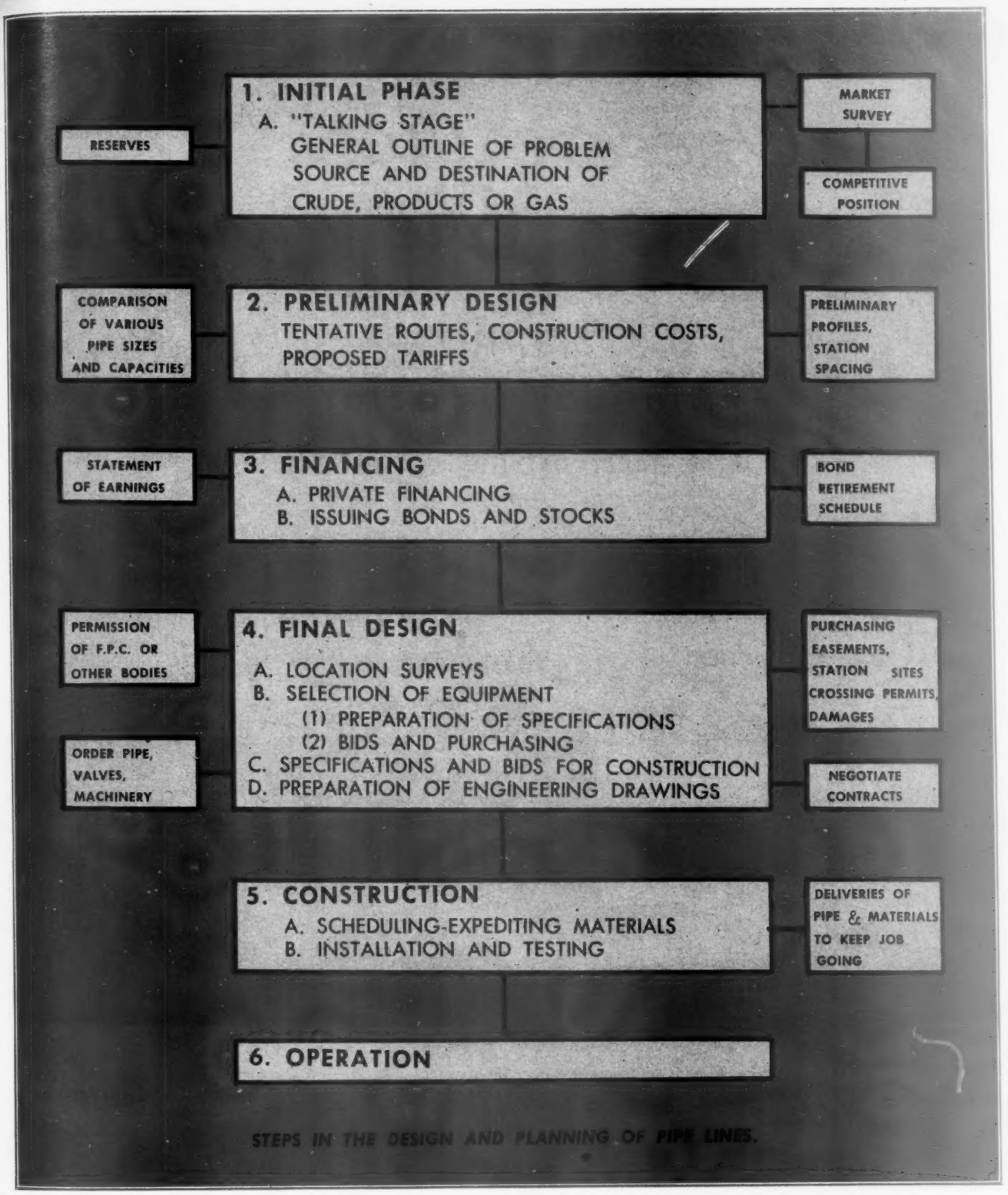

STEPS IN THE DESIGN AND PLANNING OF PIPE LINES.

is expended by the millions and there is no revenue.

A number of important tasks need to be started simultaneously and aggressively followed:

Final right-of-way must be chosen. This may require some aerial reconaissance in addition to the ground survey. Enough field men must be put out to acquire right-of-way, station and tank farms sites without undue delay which would hold up the project.

Plans should be prepared for crossing major rivers. Usually it is prudent to let separate contracts for this work.

Ordering Materials

Pipe specifications should be determined and the pipe ordered very early in the program since pipe delivery will control the beginning of construction. Coating materials can be ordered to meet pipe deliveries. Sidings for unloading cars should be chosen and shipping instructions correlated with construction schedules.

Main line valves, as well as many other valves and fittings, can be determined quite accurately from flow diagrams. These should be ordered with flanges

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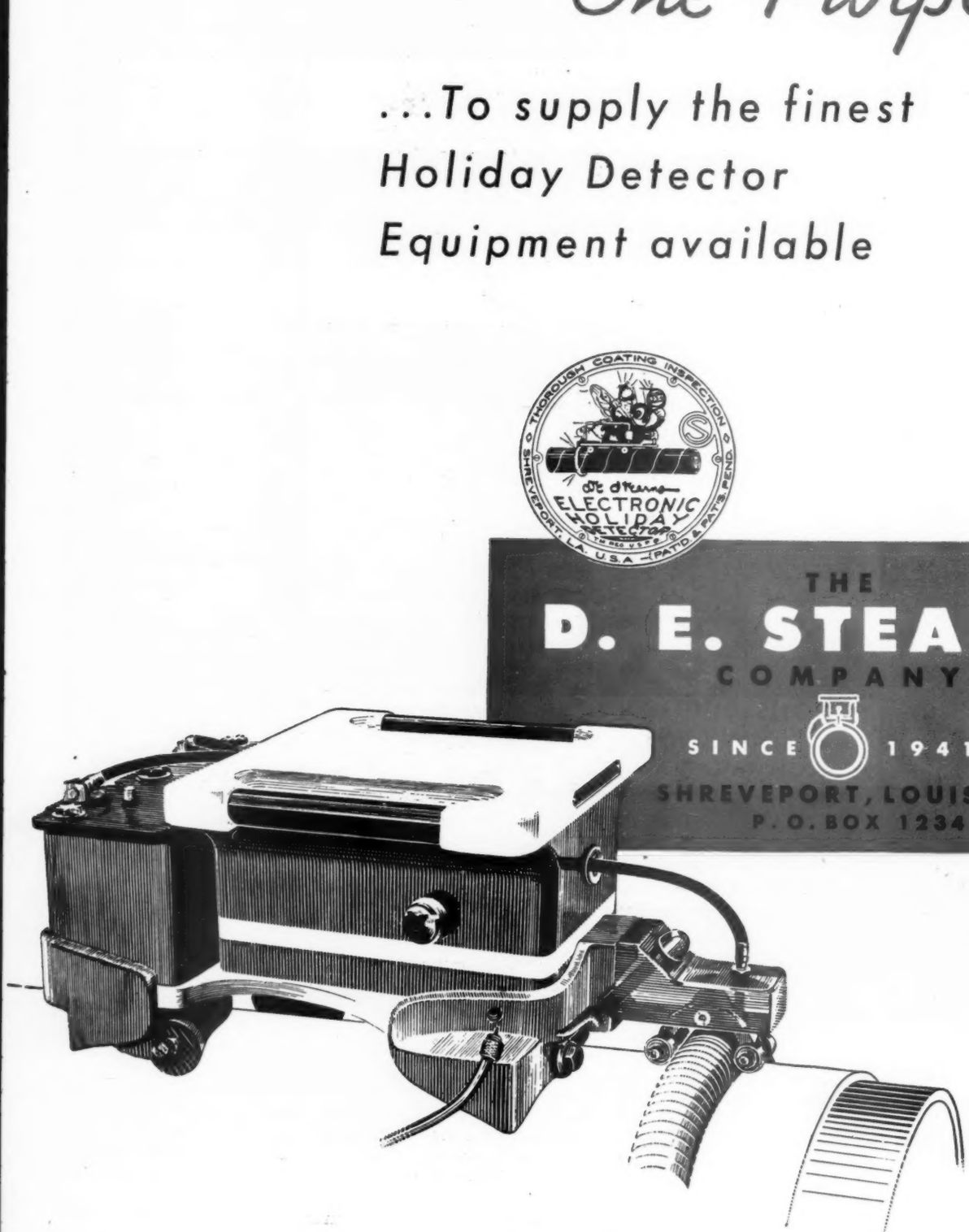


and such other fittings that can be anticipated at this time.

Specifications for main line pumps, prime movers, and important auxiliary equipment should be drawn and bids taken preparatory to ordering all these items as soon as practicable. The station building and arrangement of auxiliaries must wait on the selection of the main units.

As soon as main units are determined, foundations design and space requirements can be developed. Then the building size and overall dimensions will be known and the engineering work can proceed down to the detailed drawings, specifications, ordering of all materials, negotiating contracts, and supervising the actual construction.

Flexibility Needed

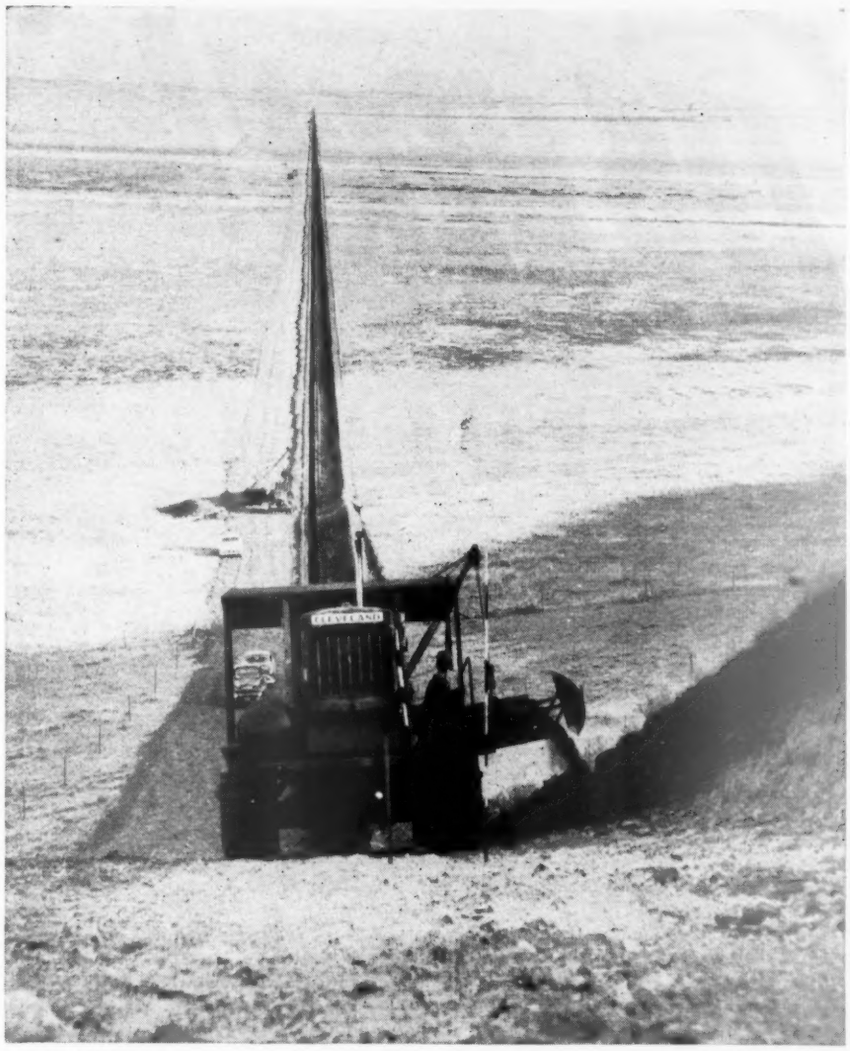
In the ideal situation, there is time during the winter months to prepare working drawings, order materials and negotiate contracts. Then, as soon as the weather is favorable, contractors take the field, pipe and all necessary materials arrive on schedule and the work gets off to a smooth start. Unfortunately, this seldom happens. Work schedules have to be adjusted, materials expedited, and all situations where contractors have no materials or drawings rectified as soon as possible.

No one who has not been through a major construction program can fully appreciate the pressure, the shouting, the apparent confusion, and the efforts on the part of so many people.

Yet there is a certain fascination in pipelining. The work goes on in spite of natural difficulties, the weather, shortage of materials. Pipe is put in the ground, tanks rise, foundations are poured, machinery is erected. Bit by bit the component parts of the system are put together and integrated until the goal is reached. The pipe line is in being, the throbbing motors pick up their loads. Operating personnel take over, and the builders look for a new assignment. * * *

Back to Products

In a registration statement field with SEC, Texas Eastern Transmission Corporation has confirmed plans to return "Little Big Inch" pipe line to petroleum products service. Texas Eastern purchased the system from the government at the end of the war and converted it to a gas transporter. In its application to SEC it was disclosed the system would be a common carrier from Beaumont, Texas, to Moundsville, West Virginia, and on to the Ohio River, and that an application also will be field with FPC requesting permission to remove this portion of the Little Big Inch from gas service.



Right on the Line

WEST OF BILLINGS, MONTANA, on the Yellowstone Pipeline job, this CLEVELAND Model 320 Pipeline Trencher is digging its way up a 250 foot hill of layer rock at an angle of better than 30° after digging 4 miles of straight trench through a dry lake bed. Inspectors for the Lowery-Continental Oil Co. maintain this is the straightest 4 miles of trench they have ever seen.

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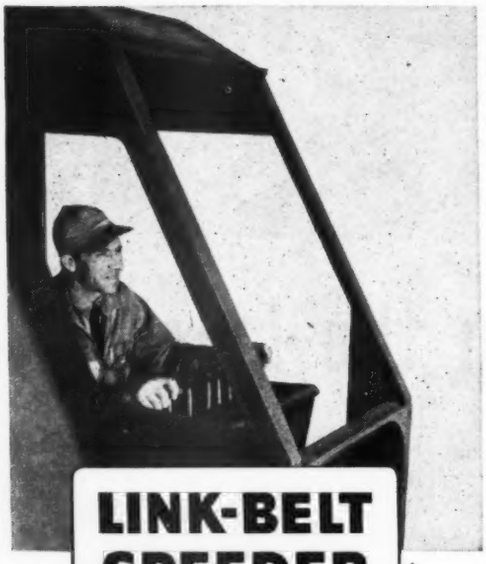
with Speed-o-Matic® power hydraulic control!

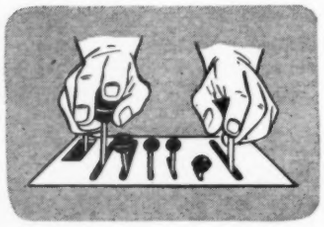


Now, for the first time in the heavy-duty 1-yd class, you can buy a machine combining unsurpassed productive capacity and maneuverability with practical transportability. In fact, an LS-98 with Speed-o-Matic control gives you the greatest productive capacity of any shovel-crane conveniently transportable over most state highways.

Two years of rugged field testing proved the LS-98 outstanding from both productive and service cost standpoints. It's an ideal machine for widely scattered operations as well as for large production jobs. Fully convertible, the LS-98 is your answer to handling more work at less cost.

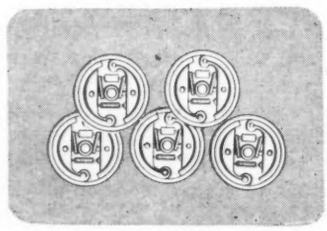
Here are only a few of the many important features that cut costs . . . boost output

Included as standard equipment are foolproof power steering and independent rapid boom hoist. These and many other advantages enable you to secure greater output at lower cost.



Fingertip, Speed-o-Matic control is easy on the operator . . . cuts end-of-the-shift letdown . . . helps increase output by up to 25%! Smooth, instant response eliminates jerk, jump or lag.

Greater usable hp, more live weight The LS-98 advanced design insures more efficient application of engine horsepower . . . incorporates greater live weight and strength to utilize extra horsepower.



Interchangeable, shoe type clutches The exclusive, self-adjusting Speed-o-Matic clutches are internal-expanding . . . easily accessible . . . all are interchangeable . . . clutch shells are alloy cast iron.

LINK-BELT SPEEDER LS-98

Get all the facts now on the great LS-98 . . . the industry's most advanced 1-yd machine

For complete details on how and why the LS-98 is your best answer to the problem of rising costs and shrinking profits, see your Link-Belt Speeder distributor. In many cases, he'll be able to give you an actual demonstration . . . let you prove for yourself why the LS-98 is great—truly the most advanced machine in the shovel-crane industry.

LINK-BELT SPEEDER CORPORATION
Cedar Rapids, Iowa

13,498

ASK FOR THE "INSIDE STORY"

See your distributor or write for the 98 Series catalog and the new booklet which gives you the "Inside Story" on Speed-o-Matic control.

BUILDERS OF A COMPLETE LINE OF CRAWLER, TRUCK AND WHEEL-MOUNTED SHOVEL-CRANES

LINK-BELT SPEEDER

XUM

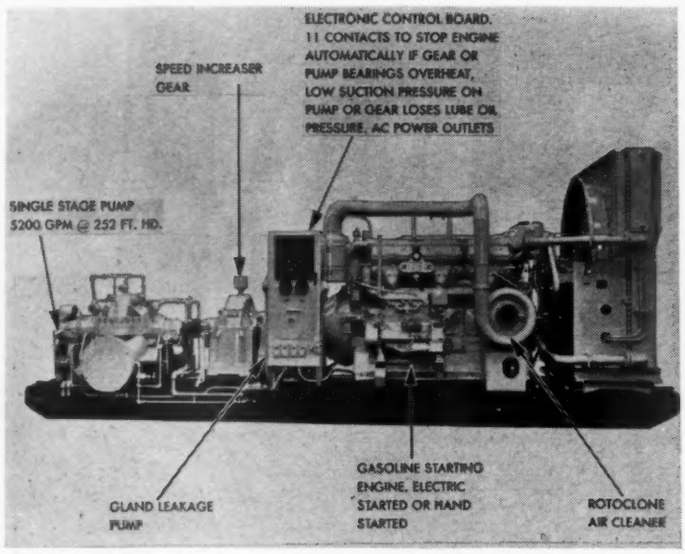

ELECTRONIC CONTROL BOARD. 11 CONTACTS TO STOP ENGINE AUTOMATICALLY IF GEAR OR PUMP BEARINGS OVERHEAT, LOW SUCTION PRESSURE ON PUMP OR GEAR LOSES LUBE OIL PRESSURE. AC POWER OUTLETS
SPEED INCREASER GEAR
SINGLE STAGE PUMP 5200 GPM @ 252 FT. HD.
GLAND LEAKAGE PUMP
GASOLINE STARTING ENGINE. ELECTRIC STARTED OR HAND STARTED
ROTOCLONE AIR CLEANER

FIG. 1. Profile view (right side) of engineered package pumping unit.

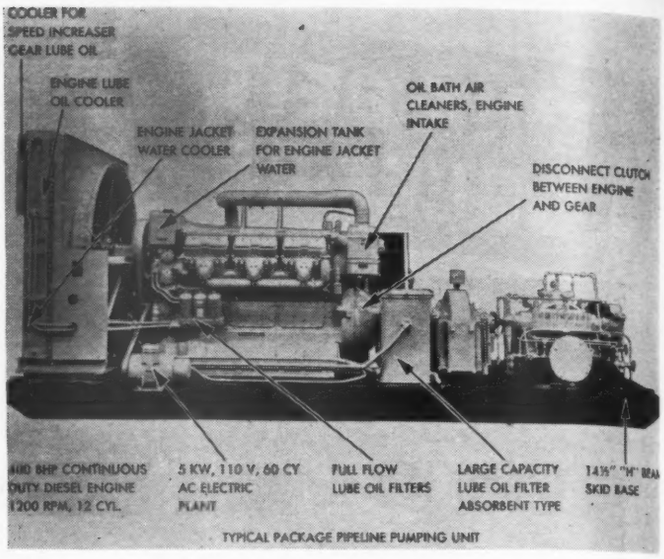

COOLER FOR SPEED INCREASER GEAR LUBE OIL
ENGINE LUBE OIL COOLER
ENGINE JACKET WATER COOLER
EXPANSION TANK FOR ENGINE JACKET WATER
OIL BATH AIR CLEANERS, ENGINE INTAKE
DISCONNECT CLUTCH BETWEEN ENGINE AND GEAR
400 BHP CONTINUOUS DUTY DIESEL ENGINE 1200 RPM, 12 CYL.
5 KW, 110 V, 60 CY AC ELECTRIC PLANT
FULL FLOW LUBE OIL FILTERS
LARGE CAPACITY LUBE OIL FILTER ABSORBENT TYPE
SKID BASE
TYPICAL PACKAGE PIPELINE PUMPING UNIT

FIG. 2. Left side profile view of packaged pump unit.

Package Pumping for Pipe Lines

Complete units ready for installation are convenient, economical; any combination of engine, pump, controls and accessories available for every type use, including new units or replacements

TOM WILLEY

CURRENT widespread interest in package pipe line pumping units is a result of the many advantages offered in convenience and economies possible in operating costs and manpower.

Financial consideration is important in weighing the advantages of the package unit and many purchasers have been surprised at the conveniences offered in connection with procurement and installation of a portable arrangement.

In purchasing a package unit, the buyer specifies his requirements in terms of barrels required in a given time, and working pressures of the line. The vendor designs and engineers the unit, and in some instances, has contributed to the design of the station, resulting in considerably reduced burden on the pipe line company's engineers.

Upon consolidation of design requirements, the unit may be assembled and tested to the purchaser's satisfaction in the vendor's shop before the installation is completed. It is not unusual for the purchaser to be relieved of the details of installation to the extent that he provides only supervisory personnel during actual installation.

The Author

Tom Willey is a member of the Caterpillar Tractor Company engine division. A graduate of Bradley University at Peoria, Illinois, Willey served a four year "hitch" in the United States Navy before joining Caterpillar in 1946. His experience at Caterpillar has been primarily with the oil producers and oil transportation firms during a period in which he was a special engine representative in Mississippi, Louisiana, and Arkansas.

He is currently working on special assignments in the engine division at Caterpillar.

Portability makes the package unit increasingly attractive, as pipe lines penetrate deeper into less settled and more remote geographical areas. Some units may be moved in one piece over existing highways on conventional high speed trucks. In cases of emergency it can be flown to remote locations. For instance, within the past six months, units have been flown to operating locations as far distant as Arabia, where the need for increased pumping capacity was urgent.

EXCLUSIVE

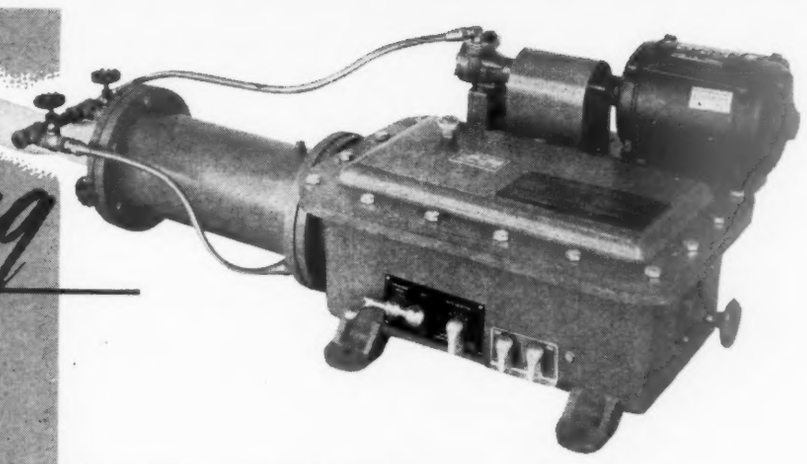
Can Be Used As Replacements

In other instances, package units have replaced units in permanent stations where the originally installed source of power has failed. In other cases, booster stations have been installed on short notice even though the booster may be required for a comparatively short period of time. In each case, package unit installation has been accomplished to the distinct benefit of the owner, either in reduced installation costs or in production that might have been lost during installation of "permanent" and more stationary equipment, or both.

Briefly, some of the advantages noted by owners of package units include:

1. **Smaller initial investment.**
2. **Increased horsepower in amount**

Announcing



THE NELSON EXPLOSION-PROOF PIPE LINE SAMPLER.....

Designed to meet a real need, the Nelson Pipe Line Sampler takes small representative samples of crude oil or refined products that are flowing in a pipe line.

(1) Fulfills A.P.I. requirement of draining sample line before taking a sample.
(2) Operates from contact on a flow meter or by built-in period timer.
(3) Takes continuous sample in small increments.
(4) Takes and holds sample from line under line pressure.
(5) Rugged, explosion-proof construction throughout.

WRITE FOR NEW, ILLUSTRATED 7-PAGE BULLETIN . . .

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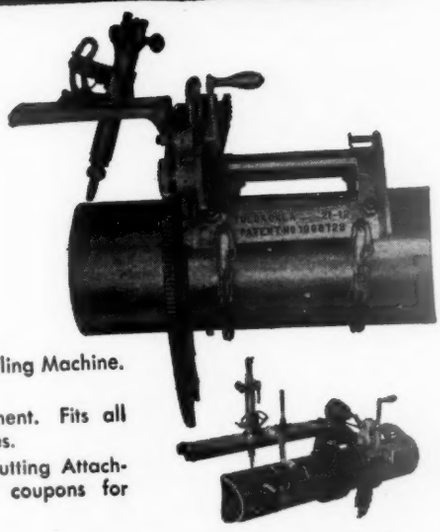
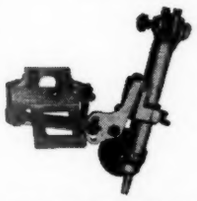
Mathey

PIPE CUTTING AND BEVELING MACHINES

- **QUICKEST IN OPERATION**
  - Just slips over pipe
  - No hinges or latches to open or close
- **LIGHTEST WEIGHT**
- **FIVE MODELS** (for pipe from 4" to 36 inches)
- **ECONOMICAL**
- **FOR RENTAL OR PURCHASE**





Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.
Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.
Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.

*COMPLETE STOCKS OF PARTS FOR ALL MATHEY and MATHEY MANUFACTURED MACHINES IMMEDIATELY AVAILABLE

C. A. MATHEY MACHINE WORKS, INC.
212 SOUTH FRANKFORT • TULSA, OKLAHOMA

TABLE 1. Typical test on two diesel 400 bhp (continuous duty) engines driving 3-stage 6 x 8 centrifugal pumps.

Basic Data

1. Duration of test	3 hr
2. Fuel consumption taken every	30 min
3. Atmospheric pressure	14.4 psi
4. Ambient temperature	68 F
5. Diesel oil consumption per hr..	
No. 2 engine	20.59 gal
No. 3 engine	20.23 gal
6. Diesel oil Btu content high heat value	19,000 Btu/lb
7. Diesel oil weight	7.296 lb/gal
8. Speed of units	
No. 2 engine 1115 rpm no. 2 pump	3300 rpm
No. 3 engine 1082 rpm no. 3 pump	3200 rpm
9. Suction pressure No. 2 pump	13 psi
10. Discharge pressure No. 2 pump.	320 psi
11. Suction pressure No. 3 pump..	320 psi
12. Discharge pressure No. 3 pump.	640 psi
13. Actual barrels pumped per hr..	2290 bbl
14. Crude characteristics:	
API Gravity—36.2 API @ 72 F	
API Gravity—35.3 API @ 60 F	
Specific Gravity at 36.2 API—.8438	
15. Engine jacket water cooled by pipe line heat exchangers.	

Test Results

	(1)	(2)	(3)
1. Time interval	60 min	60 min	60 min
2. Gallons fuel oil	44.4	38.6	33.8
3. Pounds fuel oil	323.40	281.4	238.0
4. Barrels pumped	2643	2290	2146
5. Station discharge pressure lb	640	640	555
6. Pump efficiency	77%	77%	76%
7. Brake horsepower	770	670	630
8. Total BTU input	6,148,000	5,365,000	4,540,000
9. BTU per BHP hr	7,980	7,980	8,170
10. Fuel cost per hr at 10c per gal	4.44	3.86	3.38
11. Lube oil cost per hr using Series 2 oil costing $1.10 per gal Filter cost also included	.570	.570	.570
12. Maintenance, repair and overhaul	.778	.778	.384
13. Total cost per hr	5.788	5.208	4.334
14. Total cost per bbl	.045	.0443	.049

$$BHP = \frac{GPM \times \text{weight gal} \times \text{discharge head}}{33{,}000 \times \text{pump eff.}}$$

of space formerly occupied by obsolete units.

3. **Reduced costs in terms of cost per barrel.**
4. **Package unit may be installed easily on concrete slab floor.**
5. **Complete package units may be purchased at cost equal to cost of major overhaul on large stationary equipment.**

Reduced installation and operating costs are usually the first consideration of the purchaser. Many pipe line companies in the process of rapid expansion have found that they can meet the growing pumping requirements precisely as needed by employing multiple units — adding, removing or shifting units as requirements vary. This practice achieves maximum efficiency and keeps capital outlay at a minimum. In many cases, the installation of an additional portable pumping unit on an operating line has yielded production increases that alone have paid for the entire cost of the unit, including installation, in a period of less than 30 days.

Various Fuels Can Be Used

Modern package units are equipped with engines employing a combustion system that permits the use of fuels normally considered unsuited for medium speed engines. This economy often results in the pumping engine utilizing fuel from the line it serves. The fuels vary widely. In Europe, the NATO pipe line engines must burn JP4 (Jet) fuel. In other areas there are crudes of widely divergent descriptions and analyses. Other package units use dual fuel engines operating on natural gas with a pilot injection of crude for ignition.

Pipe line company management has not and certainly is not expected to ease its persistent demands for quality to insure long hours of trouble-free, unattended operation. Modern manufacturing techniques and uncompromising research in the interests of product improvement are getting results. Today, the package pumping unit incorporates an engine with more horsepower capacity in less space than its predecessors. Top quality material, strict quality controls by the manufacturer, and manufacturing techniques, including certain hardening processes, have strengthened insurance against that bugaboo—down time.

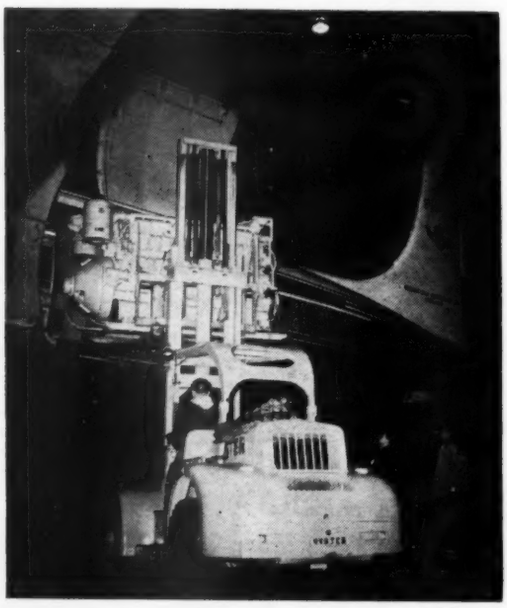


FIG. 3. Engine portion of packaged unit at Idlewild air terminal, New York, being loaded for shipment to installation in Arabia.

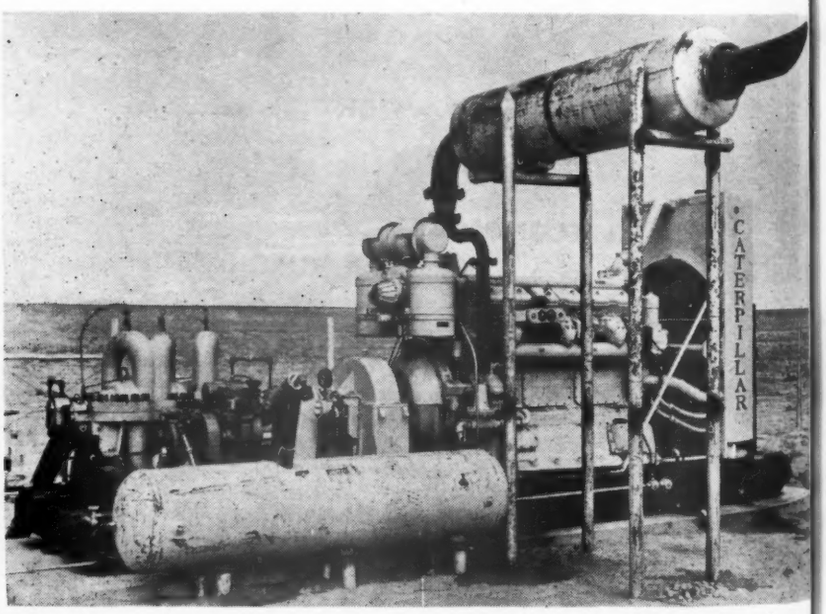
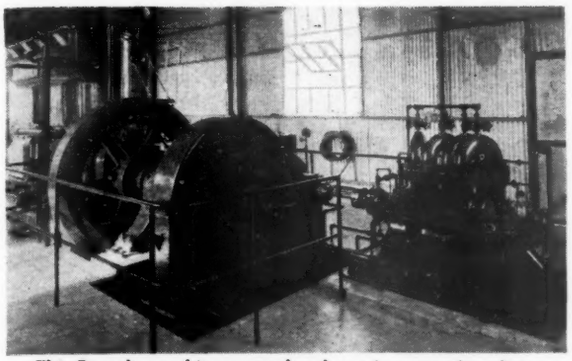


FIG. 4. Package unit installed for automatic pressure control service of temporary booster station.

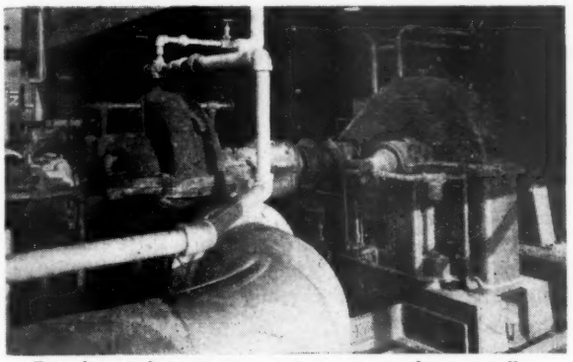
3 FACTS TO REMEMBER! when you buy speed increasers



This Farrel speed increaser has been in operation since 1932. It transmits 250 HP from a gas engine to a centrifugal pump.

1 PERFORMANCE RECORD

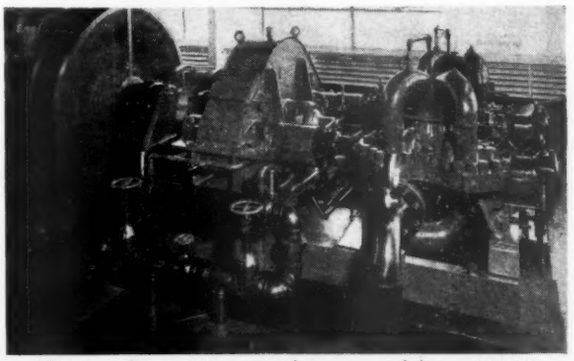
For many years, Farrel® has worked closely with the oil industry in designing speed increasers to provide continuous, trouble-free operation with a minimum of down-time for maintenance and adjustment. How successful this program has been is shown by the record. Of the hundreds and hundreds of units installed in pipeline pumping stations since 1932, *all* are still operating successfully.



Farrel speed increasing unit in an outdoor installation at a gasoline absorption plant.

2 FOR ANY SERVICE CONDITIONS

Farrel engineering can solve your special service problem. For example, units for outdoor service have been developed for successful operation under the most adverse conditions — continuous heavy-duty operation, dust, rain, sandstorms, severe heat and intense cold.



This Farrel two-pinion speed increaser delivers 300 HP to each of two pumps from a single 600 HP engine.

3 TO YOUR REQUIREMENTS

Farrel speed increasers are available in a standard line with ratios ranging from 1:1 to 12:1. For higher ratios, double step-up units are supplied with ratio range from 12:1 to 40:1. Two pinion units, designed to transmit power from a single engine to two pumps, are also available. These can be furnished with any gear ratio required.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.

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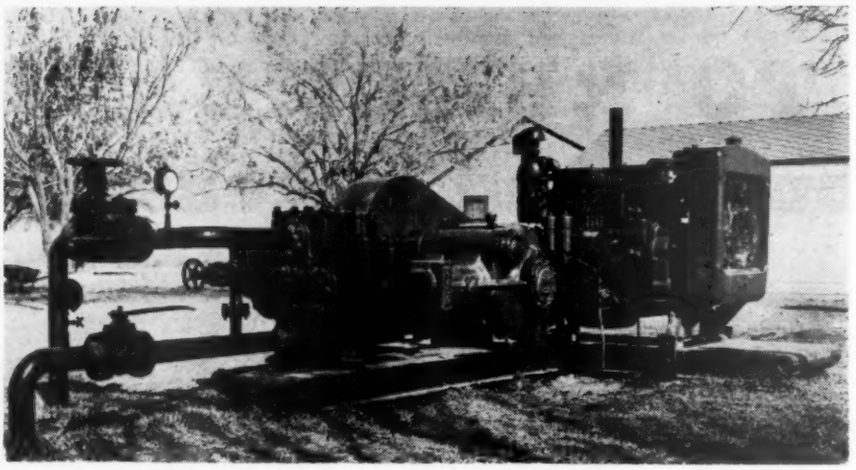

FIG. 5. Skid-mounted package unit at crude oil pumping station.

Repairs Easily Accomplished

When breakdowns do occur, easily handled, light weight parts can speed up the repair job to cut repair and maintenance bills to a minimum.

With smaller engines, it is not necessary to send cylinders for reboring and pistons for turning to special machine shops or to the manufacturer. The mechanic assumes more of the burden of repair and overhaul than does the machinist. Packaged unit vendors and manufacturers usually maintain distributor organizations with modern parts and service facilities within easy travelling distance of any pipe line station. There are exceptions, of course, such as foreign operations where the pipe line company usually has the prudence to maintain its own parts inventory and insure the availability of a competent service man acquainted with all components of the unit.

Automatic Controls

Automatic controls, safety devices and a unit that is extremely simple to operate, make another notable economy for the package unit owner. Operators, not engineers, today are efficiently handling the operation and most of the maintenance work on a multitude of pumping stations. Some of the units pump for hours — even days —without attention. This is particularly true in some remote areas. In some exceptional cases the units have delivered steadily over long periods of time without benefit of shelter.

Basic Equipment

The basic pipe line pumping unit includes:

1. **A modern diesel engine, operating at medium speed.**
2. **Cooling system, usually a radiator because it is portable and requires no raw water source and piping hookup.**
3. **Reduction gear, or speed increaser, equipped with an oil cooling system.**
4. **Flexible coupling, mounted between the engine flywheel and reduction gear.**
5. **A skid base, designed to best suit the unit for its intended application.**

For units to be moved frequently, very heavy H sections are used in constructing the base. The sections may be as large as 24-in. but 14½-in. section is the most common. The 24-in. section bases are capable of extremely rough treatment without disturbing the alignment of the engine, gear, and pump.

Starting Is Important Feature

Pipe line users of pumping units, wise in the knowledge that balky starting units at one station can neutralize the entire system, place strong em-

FIG. 6. Package unit used as emergency installation at main line station.

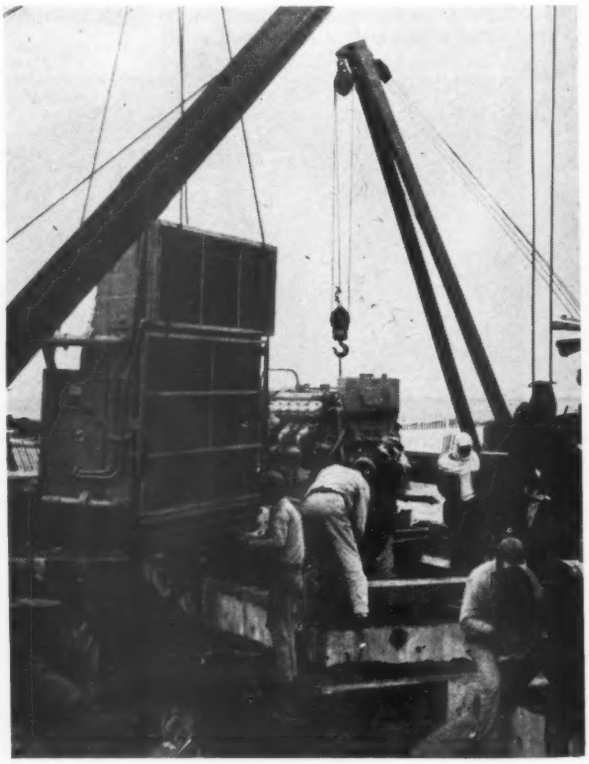

FIG. 7. Tractor and sideboom complete field installation of pumping unit package at main line station in Saudi Arabia.

When experience counts . . .

Complete facilities for any pipe line job

From first clearing of right of way through station construction, backfill clean-up and final line test, Shamrock men and machines give you custom services.

Trained personnel and modern equipment combined with 18 years experience give you satisfaction in every phase of pipe line construction—crude, products, gas lines, stations.

Shamrock Construction Company

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Microwave Towers

Keep Maintenance Costs Down

There's extra value in the advanced design of Emsco microwave towers . . . dependability plus low cost maintenance. Here's why:

(1) Every tower design meets RTMA specifications.

(2) Towers are factory-fabricated under modern, high-speed fabrication methods.

(3) Emsco towers are completely hot dip galvanized, providing protection against corrosion.

(4) Bolted construction permits quick, sure visual inspection of towers.

(5) In case of guyed towers, Emsco's unique bridle guying minimizes torsional deflection.

An unconditional guarantee backs every Emsco tower design. Every Emsco engineered tower stems from more than 25 years of experience in steel tower fabrication.

For guyed or self-supporting towers unequalled for safety . . . performance . . . economy . . . specify Emsco. Prompt delivery is assured.

EMSCO

TOWERS OF STRENGTH

EMSCO MANUFACTURING COMPANY

LOS ANGELES, CALIFORNIA

Houston, Texas • Garland, Texas

Typical Emsco self-supporting microwave installation, Houston, Texas

phasis on the importance of reliable starting. Some prefer an air starting motor connected to the engine flywheel by a Bendix drive. Compressed air is supplied from an automatic compressor and receiver, which is mounted on the base. Batteries supply power to electric starting motors in other installations.

Another method utilizes the independent gasoline starting engine connected through a clutch and Bendix drive to the flywheel of the engine. The cooling system and the lubricating oil system of the starting engine and the diesel engine are connected to permit warming of the diesel during the starting operation. In addition, jacket water heaters, either starting aids, and electrically energized glow plugs in the pre-combustion chamber, are available as cold weather starting aids.

Many Accessories Available

The customer can get what he wants in the way of additional equipment or attachments when he buys a package unit. He may obtain a large capacity fuel tank built into the base (the capacity being commensurate with the engine size), automatic or remote speed controls, an alternating current generator driven from one of the engine's accessory outlets or from a front power take-off, centrifugal type air cleaners for desert operations where sand in the air is prevalent, spark arresters, and safety shutdown or alarm devices for the protection of the engine and other equipment.

These safety devices are often in the form of temperature indicators on bearings, lube oil pressure indicator on the gear, and suction and pressure indicators on the pump. Any of these indicators may be connected to engine safety devices to shut it down in the event of malfunction in any critical area.

So reliable have these safety and control devices become that units have been installed to operate for 30 consecutive days in isolated areas without attention. Some start, stop and vary their speed automatically as line conditions dictate. Others may be controlled by telephone or radio signals from a dispatcher. * * *

First U. S. Pipe Line

The nation's first "long-distance" gas pipeline extended about 5½ miles from Newton well to Titusville, in Pennsylvania. This line was completed in 1872. Eighty years later, the nation's total mileage of natural gas pipelines was about 370,000 miles and increasing at a rate of more than 5,000 miles each year. Many lines for natural gas extend 1200 to 1800 miles.

PIPE LINE PROGRESS

26-inch line ready to be lowered in on Cobb-Rockville section of Columbia Gas Systems line.

Columbia Gas Systems Looping "Toughest Inch" with A. O. SMITH 26-INCH LINE PIPE

In the memory of the men who built it, the 262-mile Cobb-Rockville Line, now carrying natural gas from Charleston, West Virginia, to Washington, D.C., is still the "toughest inch." It was completed in December of 1949 through some of the roughest terrain for laying pipe ever encountered.

The "toughest inch" consists mainly of A. O. Smith internally expanded, 26-inch welded steel line pipe.

A portion of this line is now being looped with additional A. O. Smith 26-inch line pipe . . . evidence of satisfaction in our large-diameter welded pipe.

Again the pipe liners are conquering the "roller coaster" grades, rocky terrain, violent streams and stubborn tangle of brush to assure adequate gas supply at the Rockville terminal of the "toughest inch."

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

The A.O. Smith Casing Mill is operating at capacity to supply vitally needed casing for the Oil and Gas Industry.

Through research ...a better way

A.O.Smith

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International Division: Milwaukee 1

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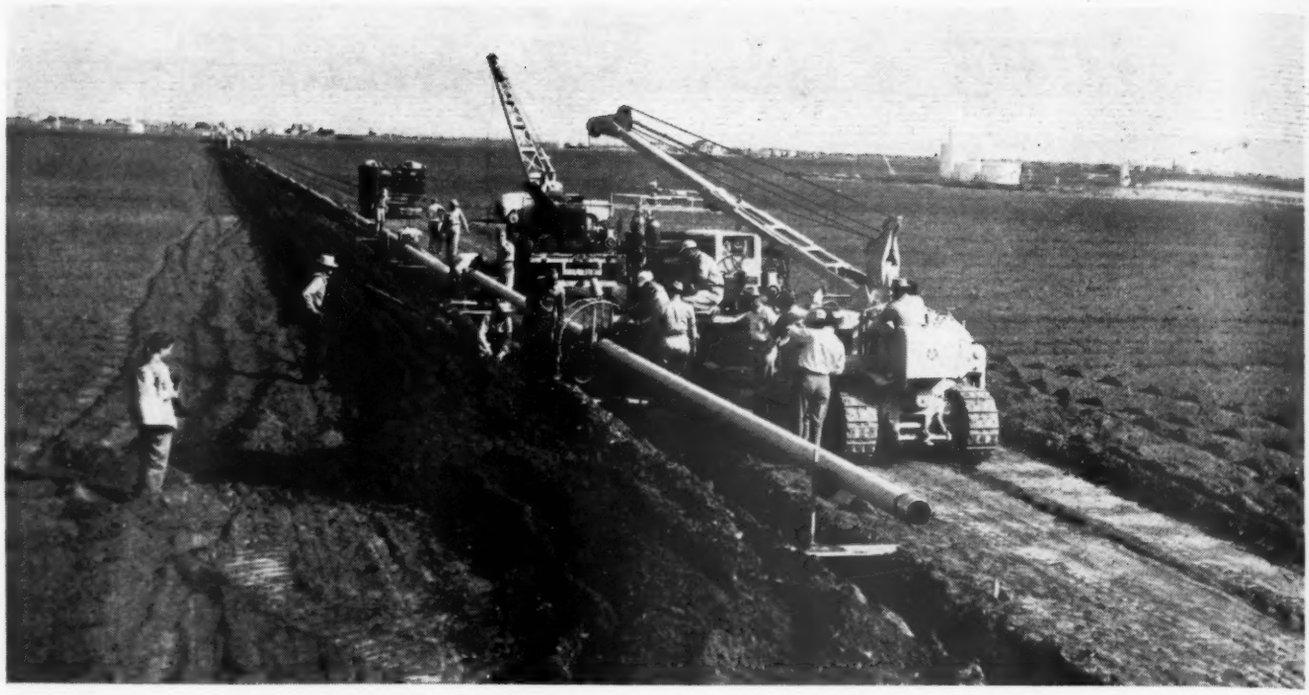


General layout of spread showing minimum equipment needed, method of laying line. Darby Construction Company, McAllen, Texas, was contractor for the 12-mile, 8-in. gas line.

All-Aluminum Gas Line Is Unique Installation

Lightweight aluminum pipe used on 12-mile, 8-in. gas line in South Texas is welded by new-type automatic welding machine; method involves less equipment, manpower

BILL SLOCUM*

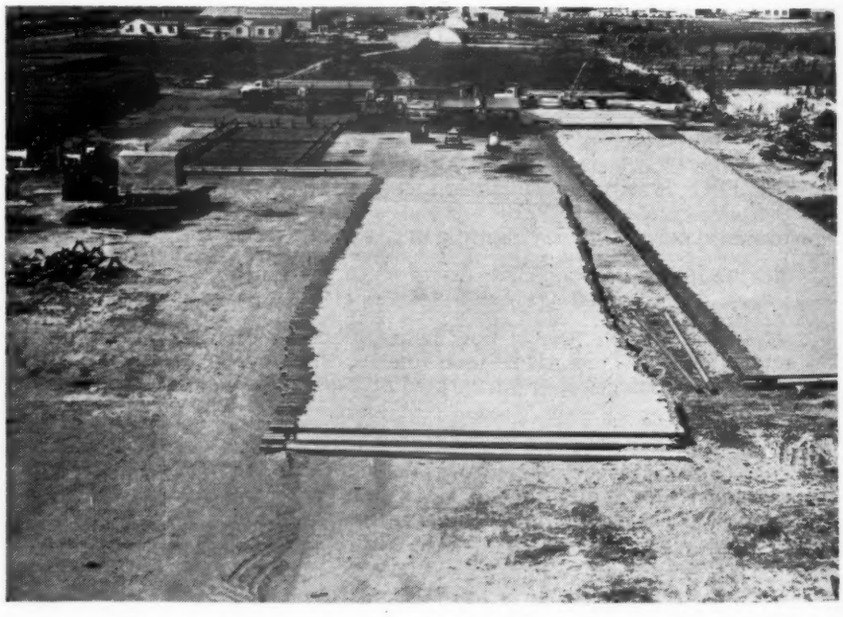
EXCLUSIVE

THE Reynolds Metals Company, producer of aluminum metal products, has just completed a pipe line that could possibly revolutionize certain phases of the pipe line industry and otherwise point the way to saving a great deal of money for the petroleum industry.

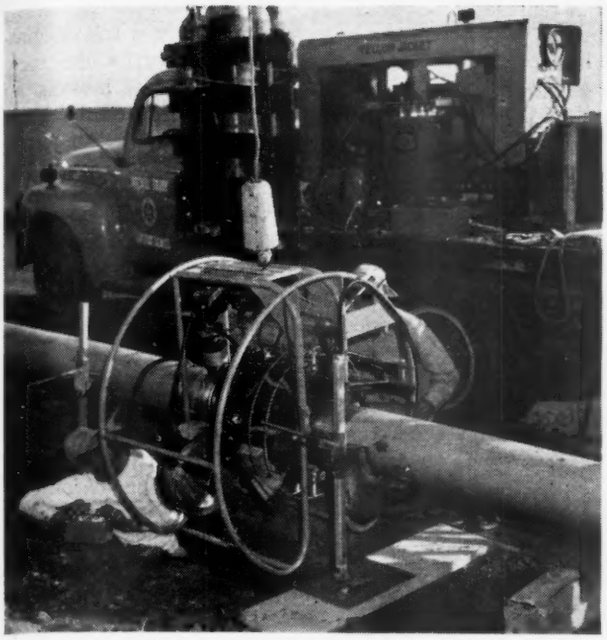
The line is short in distance, only 12 miles, but is is long in the aspect that it could solve two of the most troublesome problems in the industry — that of corrosion and weight.

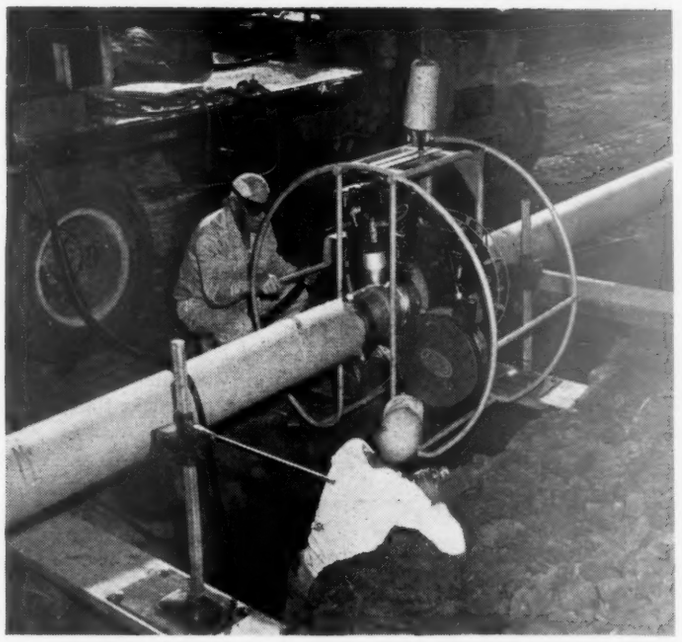
The completed line is a high pressure gas carrier extending from the White Point gas field northwest of Corpus Christi, Texas, to the Reynolds La Quinta Alumina plant on Corpus Christi Bay. It was fabricated of 40-ft sections of 8⅝-in. pipe of ¼-in. wall thickness. The new line was designed to handle 500 psi gas for plant operations at La Quinta, but it was finally

*Oil Editor, The Times Herald, Dallas, Texas.



Pipe was coated and wrapped in Rosson-Richards yard before moving to right-of-way.





Automatic welding machine at work on all-aluminum gas line. Welder is supported by jacks on timbers spanning ditch and joints are welded over ditch.

Key to use of aluminum line pipe is the automatic welder. It weighs approximately 200 lb and is supported by line from side boom tractor and jacks. Pipe is lined up over ditch, special clamps grip pipe on uncoated areas, and machine makes a four-pass weld in about 2 minutes. Shielded metallic-arc process is used, with either argon or helium, or mixture of the two, used as inert gas shield. Wire is fed from reel to welding nozzle by one synchronized motor while another motor drives unit around pipe.

tested with gas at 1000 psi. A 40-ft joint of aluminum pipe weighs approximately 300 lb.

For high pressure lines, aluminum pipe costs about 1.8 times as much as steel pipe, both delivered to a given job. It has been found, however, that in contrast to using older welding and construction methods, installation costs have been cut about 30 per cent by using smaller equipment, stringing by hand, and in various ways utilizing the light weight of aluminum.

In low pressure systems, such as those used for gas gathering, a modified wall aluminum pipe can be used that has a bursting pressure, after welding, of about 1200 psi and is considered adequate for gathering operations. Using this product, a gathering system could be installed at a low overall cost.

This development is of particular importance to the oil pipe line and gas transmission industries. Aluminum pipe, while higher in cost than steel, has important advantages including light weight, non-corrosiveness, less maintenance expense, smoother inside walls.

The inside surface of aluminum pipe

Coating and wrapping welded joint after automatic welder has passed. Pipe joints were yard-coated prior to welding.

Two workmen handle 40-ft joint of pipe, demonstrating how lightweight can be utilized.

is smooth, which means less friction and less pressure drop, with consequent savings in transmission cost. Less friction means less heat and less heat means less pressure, reducing the possibility of damage to lines.

Aluminum is non-corrosive, and is not attacked by the sulfur present in some crude petroleums, and suggests the use of the material in other installations such as tubing, casing, and storage tanks.

Key to the use of aluminum in pipe lines is a new automatic welding machine that Reynolds developed in conjunction with Air Reduction Sales Company. To date, the unit represents an investment of approximately $40,000. It weighs about 200 lb and is suspended over the line by a side boom after the pipe has been lined up for welding.

A minimum of equipment and men is required for the line-laying process. The pipe is lined up over the ditch and placed on specially designed jacks where it is spotwelded to hold it in place. The jacks rest on a wooden span straddling the ditch.

In the actual welding process, only two units are involved. One is a flatbed truck that carries the portable power unit for the welding machine. The other is a tractor that follows the truck. Its side-boom carries the specialized welding machine, moving it from one joint to the next. Only three men are engaged in the welding operation. One drives the side-boom tractor, a second operates the welding machine with a pushbutton control and drives the truck with the power unit, and the third guides the power lines while the unit is in motion and then guides the welding unit as it moves down the line.

Special clamps grip the pipe as the automatic welder is lowered over it, and a pushbutton starts the welding process. Automatic controls maintain proper speed and welding conditions at the arc. The machine completes a four-pass weld on the line in about 2 min. Mitchell Darby, of Mitchell Darby Construction Company, McAllen, Texas, estimated that approximately one mile of line per day could be laid with one machine.

The automatic welder uses the metallic-arc process developed for sound aluminum welds at high speed. These welds have withstood pressures up to 1800 psi without breaking.

Aluminum wire is fed from a reel directly to the welding nozzle of the unit, where the wire is melted by an electric arc. At the point of the actual weld, the wire, arc, weld and aluminum are protected by a shield of inert gas. Either argon or helium, or a mixture of the two, are used for this purpose.

The unit has two motors that are synchronized. One drives the unit around the pipe and the other feeds welding wire from the reel.

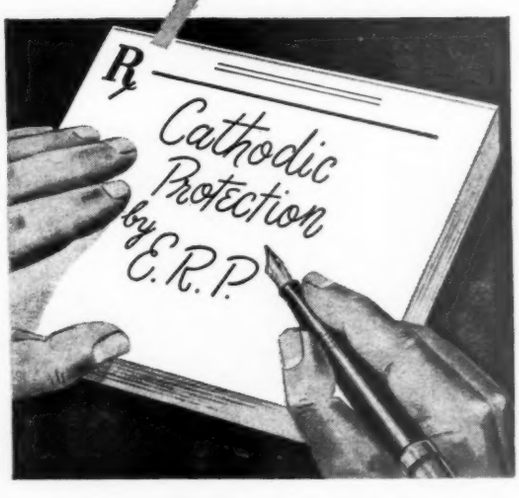
Although pipe in the new White Point-La Quinta line was yard coated and wrapped, this is considered unnecessary in many instances.

If aluminum pipe is to be wrapped, it does not require cleaning after storage to remove mill scale or rust. Wrapping of aluminum pipe costs about 30 per cent less. This particular line was coated with 3/32-in. bitumastic enamel, followed with a glass fiber wrap and 60-70 lb kraft paper. After the joints are welded they are wrapped in the same manner by hand.

Another advantage of the lightweight material is that damage to yard-wrapping is minimized in handling.

The Reynolds company obtains its raw bauxite ore from Jamaica. It has two ships constantly plying between Jamaica and Corpus Christi. A round trip takes about 9 days. At the La Quinta plant the ore is reduced to alumina, and another unit nearby then makes the aluminum pig ingots, which are shipped to a fabrication mill in Phoenix, Arizona, where the finished pipe is extruded. ★ ★ ★

℞ FOR CORROSION...



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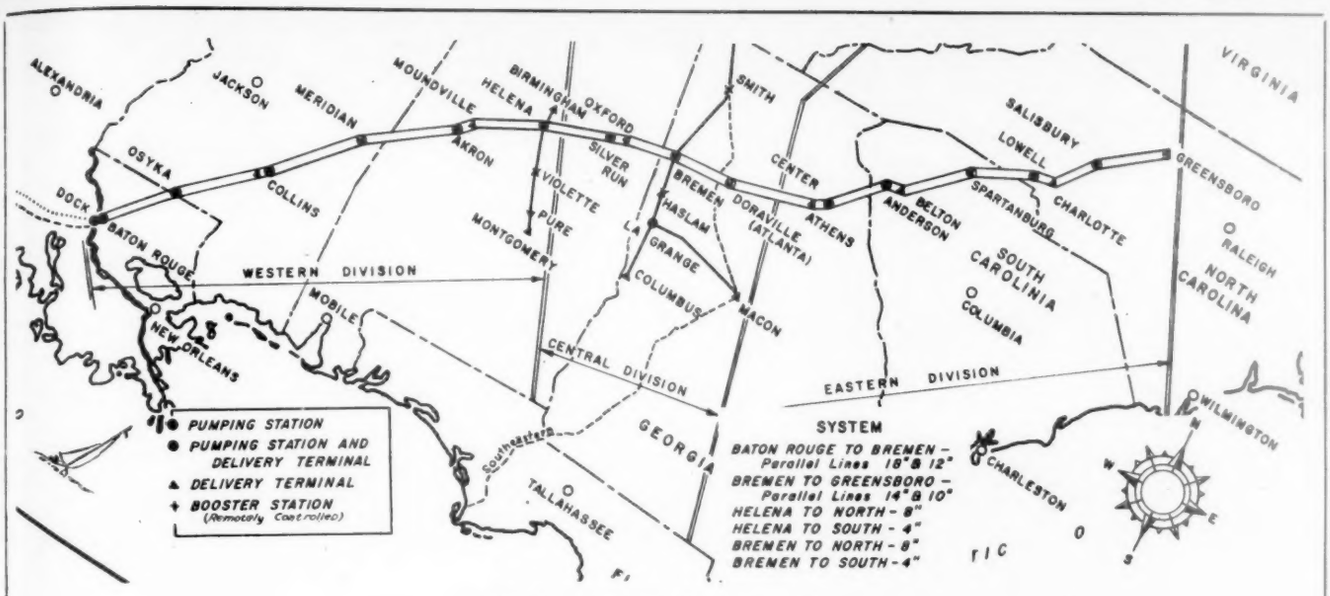

FIG. 1. Plantation Pipe Line system.

Maintaining all-electric pipe line requires proper scheduling, correct use of personnel and equipment

Products Line Electrical Equipment Maintenance

R. M. CULVER, JR.

THIS discussion pertains primarily to electrical maintenance on an electric products pipe line such as Plantation Pipe Line Company operates. Plantation operates a parallel main line system with branch laterals as shown in Fig. 1. The total connected horsepower on the system is 90,000, with an approximate capacity throughput of 221,000 bbl per day. Pumping stations are located on 60 mile spacing for both lines. All main line pumps are centrifugal and are driven by 600 to 900-hp, 2300 v, explosion resistant induction motors.

Fig. 1 shows the system to be divided into three divisions. For simplicity and more detail, this article will deal with electrical maintenance of the Western Division only. Maintenance personnel, equipment, and requirements are uniform throughout the system except for the 8-in. lateral out of Bremen, Georgia. Specialized technicians are employed to maintain the microwave stations on the 8-in. lateral.

A typical main line station, such as Osyka or Akron, houses two 900-hp units on the 12-in. line and three 900-hp units on the 18-in. line. Baton Rouge station has an additional 900-hp standby unit on each line. Helena station has one 600-hp unit on the Birmingham lateral and one 300-hp unit on the Montgomery lateral.

Violette station, on the Montgomery lateral, is an automatic station operated by teletype from Helena station. Violette houses one 300-hp unit. The dock station utilizes two 450-hp units and three 150-hp units. Baton Rouge station has 37 storage tanks, each having either a 150-hp or 300-hp booster unit located at the tank. All main line stations have provisions on the 18-in. line for an additional 900-hp unit, which can be installed when increased throughput requires it.

In order to compare the maintenance load to the personnel required, a list of electrical equipment in the Western Division, maintained by the division electricians, is as follows:

32 — 900-hp motors and associated switchgear and control equipment.

48 — 150 to 600-hp motors and associated switchgear and control equipment.

95 — 1 to 40-hp auxiliary motors.

137 — Motorized valve operators.

2 — 2300 v substations at each main line station.

Electronic pressure and flow con-

EXCLUSIVE

The Author

Robert M. Culver, Jr., joined Plantation Pipe Line Company after separation from the Army Air Force in 1948 and is presently electrical foreman of of the Western division with headquarters in Baton Rouge, Louisiana. This covers supervision of the inspection and maintenance of division electrical equipment and the installation of new electrical equipment (except equipment installed by contractors.)

Culver is a graduate of Georgia Tech with a B. S. in electrical engineering.

XUM

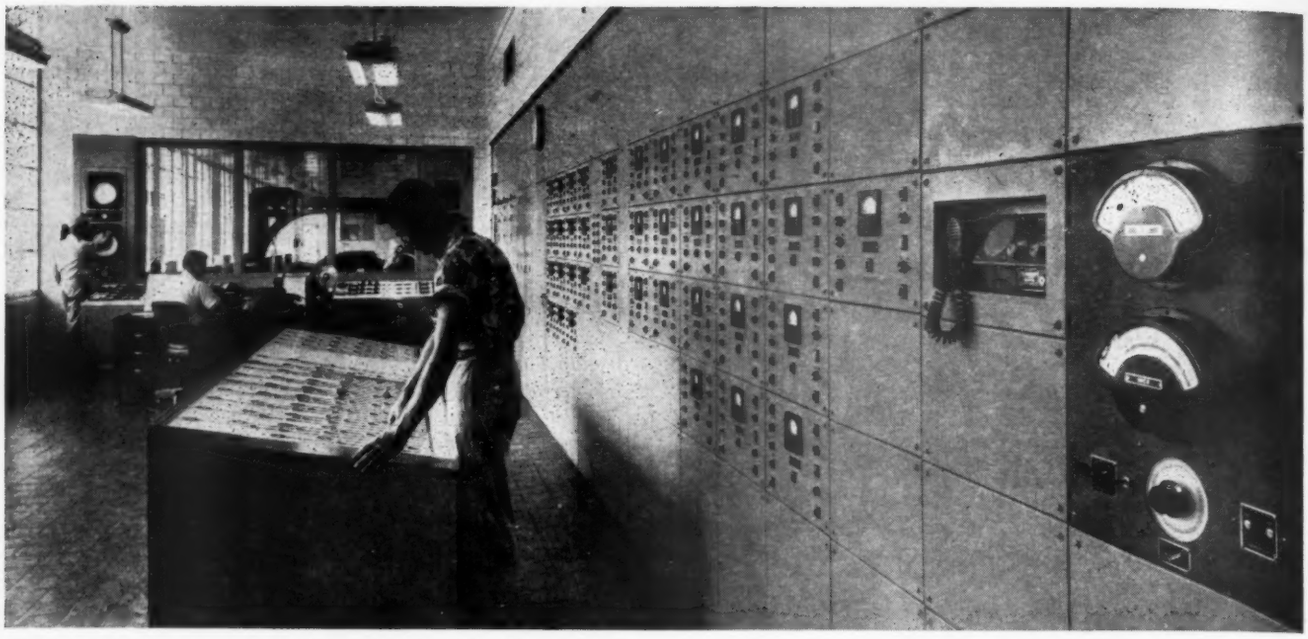

FIG. 2. Control room at Baton Rouge station, showing control panels, operation desks. Products received here into tankage, shipped for delivery to 12 and 18-in. lines.

trollers at the six main line stations and Violette station.

Electronic pressure indicators at the six main line stations.

37 — low level tank alarms on product storage tanks at Baton Rouge station.

Miscellaneous items such as station and terminal heating and lighting, residence wiring and appliances, emergency radio eqiupment.

Maintenance of the above equipment in the Western division is achieved by four electricians and one electrical foreman. Two electricians and the foreman are headquartered at Baton Rouge, and two electricians are headquartered at Akron, Alabama. Two ¾-ton utility trucks and one passenger car are used. Each truck carries a set of tools and testing equipment.

From the above, it is obvious that work requirements, personnel, and tools are present; but to obtain effective maintenance some type of plan or maintenance schedule must be incorporated.

Preventive maintenance must be a repeating process and must repeat on a well calculated cycle. This cycle has to be determined by the maintenance foreman. Manufacturers' equipment data are helpful, but maintenance re-

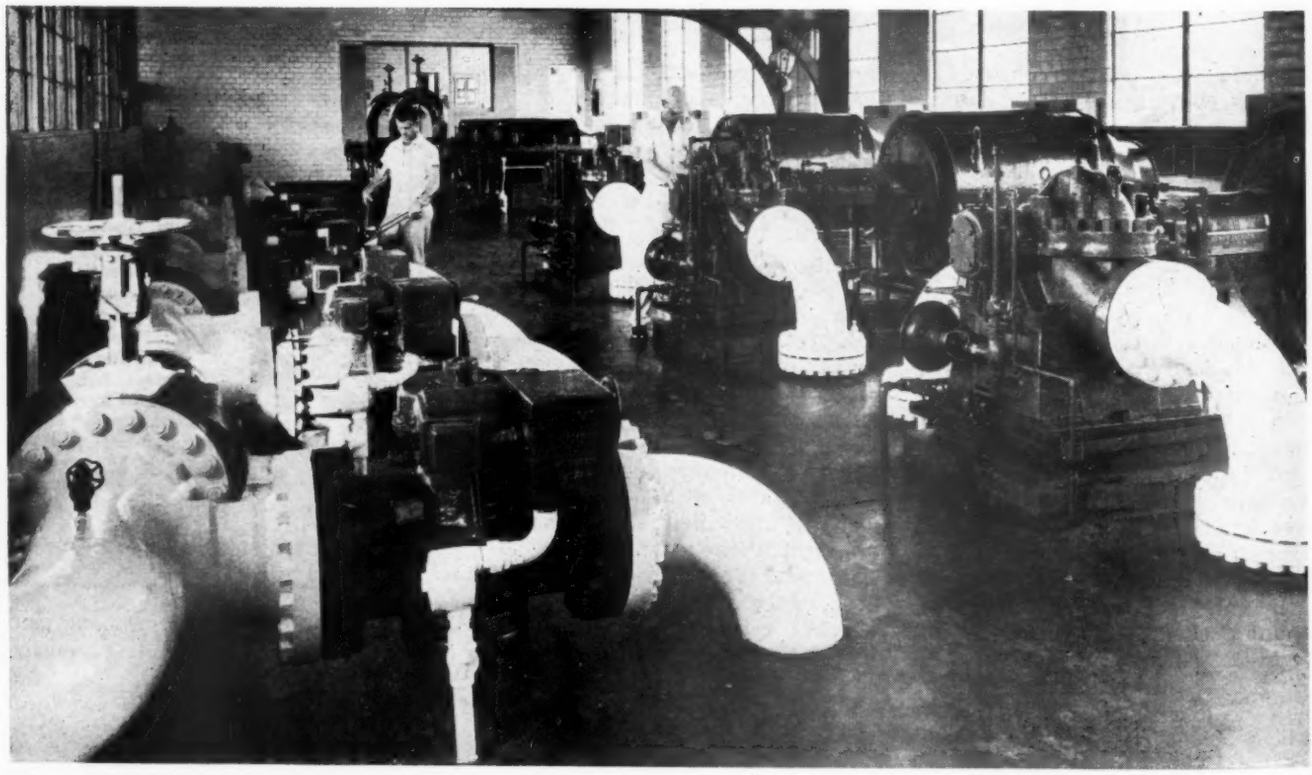

FIG. 3. Typical pump room for 12 and 18-in. lines. Akron station near Tuscaloosa, Alabama, has five 900-hp motors driving centrifugal pumps. Three are used on 18-in. line and two on the 12-in. line.

quirements must be determined on the job for each particular piece of equipment. These requirements vary, depending on use and location.

For example, 2300 v oil circuit breakers (start and run) for a main line unit at Baton Rouge station require less maintenance than the breakers for a main line unit at Helena station, because Helena starts and stops units during line take-offs between Baton Rouge and Helena, while Baton Rouge runs continuously. Contactors and control circuit equipment at the Dock station require more maintenance than those at Akron because the Dock station is located in a highly corrosive atmosphere near chemical plants, whereas Akron is out in the open country.

Records Best Method

There are different methods of maintaining equipment; the best seems to be the written record method. This written record can be simple or elaborate, depending on the need. In the Western Division, the "Maintenance Record Manual" is used. The manual is compiled by the foreman and lists by stations all the equipment with a place for dates and remarks. In the back of the manual there are brief maintenance instructions for each item listed in the manual.

For example, under Meridian station, Item No. 3 is "Oil Circuit Breakers," with a line for each of the five units. In the back of the manual under "Routine Electrical Maintenance, Main Line Stations" Item No. 3 reads as follows:

3. Oil Circuit Breakers Main Line Units:

A. Drop tank and inspect. Every 4 months.

B. Megger motor leads. Every 4 months.

C. Check linkage for correct pull-in. Every 4 months.

D. Change oil. Every 12 months.

E. Check closing mechanism. Every 4 months.

1. All bolts for tightness.
2. All pins for keys.
3. Correct adjustment on "H" bar.
4. Drum switches for correct contacting.
5. Wire connections on drum switch and terminal block.
6. Vacuum clean.

As stated above, the periods of service will vary, depending on the number of operations.

Special Manuals Used

In the case of the Western division, where the maintenance department is divided, three maintenance manuals are used. One of the electricians at Baton Rouge keeps the records for Baton Rouge, Osyka, and Collins. An electrician stationed at Akron keeps the records for Meridian, Akron, and Helena. These records are transcribed periodically to a master manual kept by the foreman at Baton Rouge.

At first thought, this Maintenance Record Manual may appear to be a big job to compile and troublesome to keep up, but its use proves its worth. Some of the advantages of the Maintenance Record Manual are as follows:

1. A definite reminder for preventive maintenance work.
2. Very helpful in making out weekly or monthly work schedules.
3. Affords a written record of equipment performance.
4. Very good aid for job training of new men.

The goal of every maintenance foreman is to achieve a sound preventive maintenance schedule. This type of maintenance program has proved very successful in the Western Division of Plantation Pipe Line Company. The same program could, of course, be adapted to any type of work which requires routine maintenance. * * *

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Even with these high temperature characteristics, the minimum softening point of Pitt Chem Hotline Enamel is only 240° F. The new enamel has less tendency to cold flow than any other coal tar coating. This quality, combined with its exceptional hardness and non-flow characteristics, indicates that a much higher resistance to soil and pressure stresses can be expected with Pitt Chem Hotline Enamel.

Pitt Chem Hotline Enamel is ideal for the following applications: On gas pipelines where service temperatures are above 100° F. In areas where excessive soil stress conditions prevail, or where the backfill and trench are rough, full of stones and rough objects which normally penetrate softer coatings. On all types of pipelines where ground temperatures are high most of the time.

For more information on this revolutionary advance in pipeline protection, call or write today for free Pitt Chem Hotline Enamel brochure.

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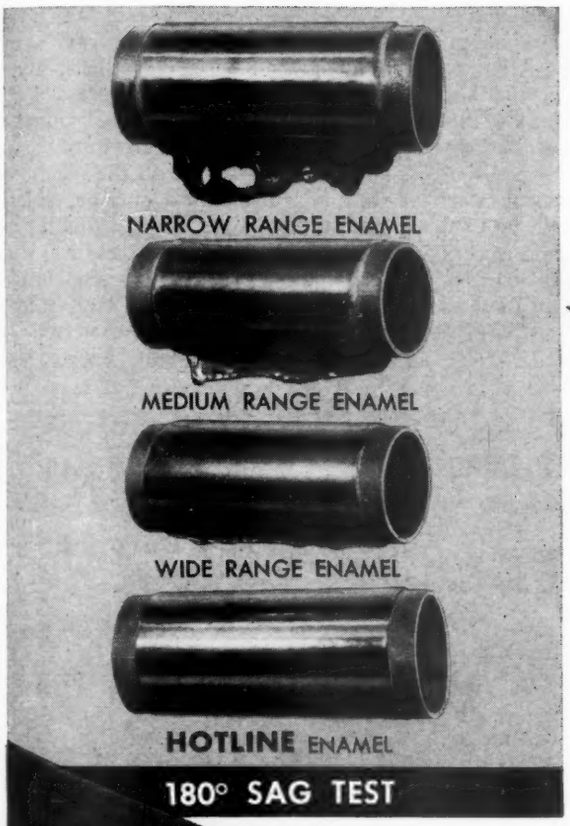
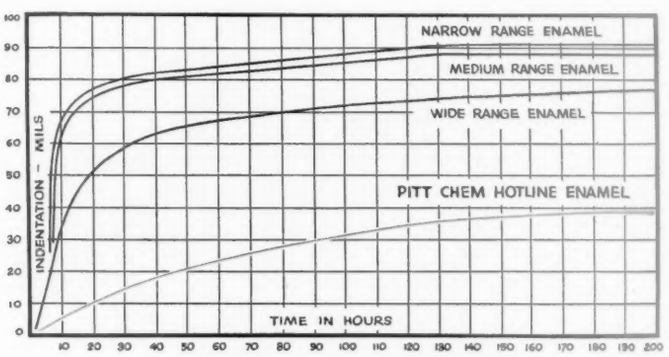


Proof of HOTLINE'S Resistance to sagging at high temperatures

These are actual pictures of sections of pipe coated with four different grades of pipeline enamel. These sections were exposed to 180° F. sag test temperatures. Note that only Pitt Chem Hotline Enamel resisted sagging.

Proof of HOTLINE'S Superior Resistance to soil stress damage

The chart below shows the degree of penetration that occurs when the three popular grades of enamel and Hotline are subjected to a pressure of five pounds psi. and tested over a period of 200 hours at 120° F. Pitt Chem Hotline Enamel's resistance to penetration is almost twice as great as any of the other three grades.



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Comparative Test in High Resistivity Soil of

ANODES VS RECTIFIERS

What type protection to use? Here's how Southeastern Pipe Line conducted tests and analyzed results in determining pipe protection for its lines in areas of high resistivity soils

H. C. VAN NOUHUYS

ONE of the first problems confronting the corrosion engineer who desires to mitigate the corrosion of some structure is whether to use galvanic anodes or rectifiers to do the job.

Although extenuating circumstances sometimes preclude the use of one or the other, it is believed that in the average case economics will dictate the answer.

Management is rightfully curious over the relative costs and merits of the two systems, because cathodic protection, though usually well justified, can also be expensive, and cost differences between systems providing equal protection may even reach a ratio of 7 to 1 as in the example following.

Although laboratory results, manufacturers' data, and the field experience of others may be of real value in solving the problem, there is no substitute for on-the-spot field research and test installations that provide protection at the same time that bona fide design data are being obtained.

Economics Determination

In this case, the problem was to determine the most economic system for the 120 miles of 92 per cent 6-in. pipe from Atlanta, Georgia, to Chattanooga, Tennessee.

Information already on hand was as follows:

(a) Several hundred test holes dug in 1947 revealed general pitting over the entire distance and indicated the need for solid protection.

(b) A long line current survey in 1950 revealed 240 anodic areas or an average of 2.2 per mile.

(c) Near completion of a 25 rectifier system in the ultra-high resistivity soils from Port St. Joe, Florida, to Atlanta, designed on the basis of lowering the pipe to soil potential .3 of a volt with respect to remote copper-sulfate electrode showed that rectifiers averaged about three amperes per mile between protection points, while

(d) Two rectifiers previously installed mid-way between Atlanta and Chattanooga were averaging 10 amp per mile between protection points, thus indicating soils having three-tenths the resistivity of those below Atlanta.

(e) Other cause for belief that soil resistivities were lower was the fact that one of the ground beds had a relatively low resistance for the number of anodes installed — six vertical steel rails averaging 13 ft in length in 15-ft holes with an average spacing of 175 ft gave us a 1.1 ohm ground bed. Applying these figures to Dwight's curves we find an average soil resistivity of 3760 ohm-cm.

(f) The other ground bed was originally similar in lay-out but had an 8.33 ohm resistance and lay in soil typical of that found below Atlanta, which was an indication that the resistivity situation below pipe depth must be spotty—with both high and low areas.

(g) Two widely separated magnesium anode tests had previously been made, which showed in the neighborhood of 10 milliamp outputs or less. One of these was above Atlanta, involved only seven anodes, and was considered too short a test to be conclusive.

(h) Four approximately 1000-ft long ribbon test installations, two of which were above Atlanta, showed suc-

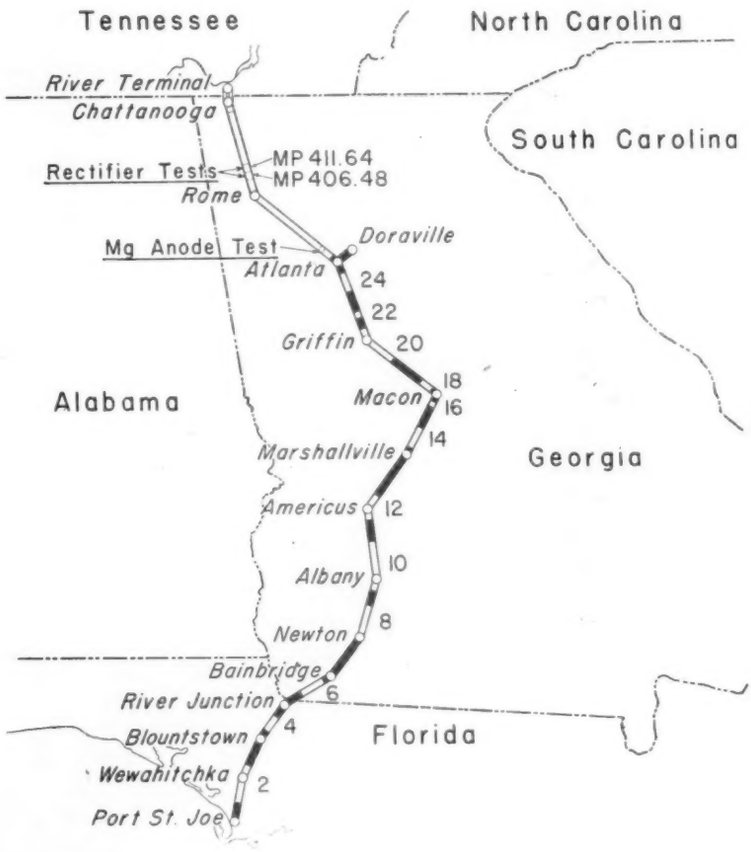

FIG. 1. Geographical location of the subject tests. Map shows cathodic protection system of the Southeastern Pipe Line Company.

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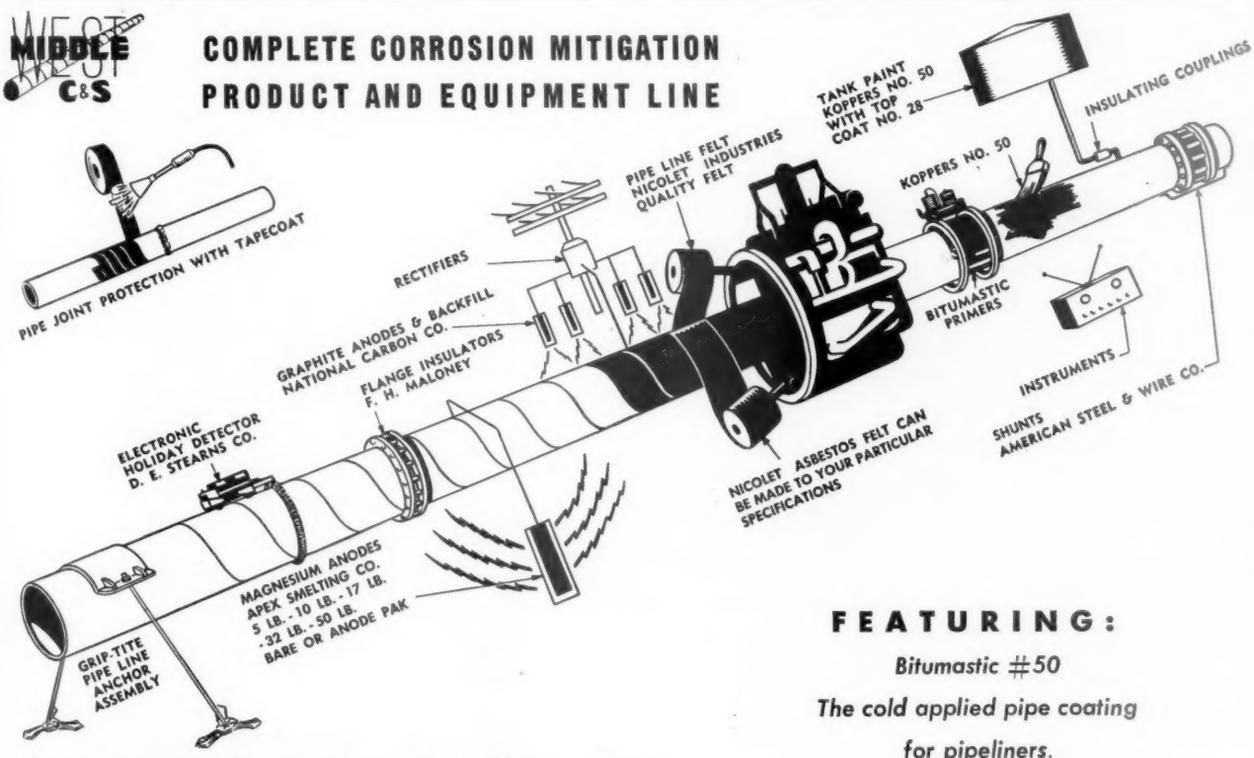
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The Author

Herbert C. Van Nouhuys, corrosion engineer for Southeastern Pipe Line Company, has been engaged in various engineering phases of pipelining since 1939. He received a B.S. degree in electrical engineering from the University of Michigan in 1934. During World War II he was with the Signal Corps and Air Corps as a training center staff officer, and as a technical officer at Radar Research and Development Laboratories. He is presently the southeast regional chairman of the National Association of Corrosion Engineers.

cessful suppression of anodic spots on bare pipe with average current densities ranging from .03 to .30 ma per square foot. Ribbon was not considered as a long range solution however due to the fact that it would sacrifice most quickly where needed most, and its life at an anodic spot would be difficult to estimate.

These experiences lead to the conclusion that if the lower resistivity soil was prevalent over the 110 miles to be protected, a decision should be made to either continue use of the rectifier system or to revert to magnesium anodes if they should prove the more economic.

To settle the matter, 301 magnesium anodes of the 17 D variety, packed in special backfill, were installed on 50-ft spacing over a 2.84 mile stretch, and data obtained were compared with test data obtained from the 2 rectifiers.

Fig. 1 shows the geographical location of the subject tests and the existing 25 rectifier solid protection system over approximately 350 miles of 8-in. bare pipe. Alternate black and white spaces are used to indicate miles of protective spread from each rectifier. For simplification, only the even numbered rectifiers (white spaces) are listed. Towns shown are pump station and/or terminal locations.

Test Results Compared

Briefly, answers were needed first to the following questions:

(a) What average and minimum current densities would be obtained from magnesium anodes?

(b) What average and minimum current densities would be obtained from the rectifiers?

(c) Would the anode outputs be adequate to suppress hot spots at 50-ft spacing? If not—at what spacing?

Answers obtained were as follows:

(a) Average anode current density—.135 ma per sq ft. Average rectifier current density .863 ma per sq ft. This is a ratio of 6.4 to 1.

(b) Minimum anode current density—.010 ma per sq ft. Minimum rectifier current density .174 ma per sq ft. This is a ratio of 17 to 1.

(c) Over the 2.84-mile course, 23 hot spots were found at anode locations. A two electrode, soil-to-soil potential test, described later, was run at each anodic spot. Of the 23 locations, anodes failed to suppress the hot spots in 10 of the 23, or 43½ per cent.

A special test made midway between two adjacent anodes (Nos. 79 and 80) which were suppressing hot spots showed that suppression was not being accomplished at the midpoint.

The conclusion was drawn that 25-ft spacing of anodes would be required and even closer spacing might be necessary in certain spots.

Description of Fig. B —Magnesium Anode Data

Anodes 1 to 43 were installed in a wooded section uninterrupted by cultivation, after which anodes 306 to 49 were installed. No anodes were installed for numbers 48-44, the total being 301.

Creosote-impregnated stakes containing numbered brass washers were driven three feet south of each anode.

More complete data were obtained for anodes 1 to 43 than for the remaining anodes because this stretch was free of cultivation, test stakes were not apt to be rooted out, and because it contained marshy spots as well as hills, made an ideal test site. As the test turned out, 1 to 43 were in the soil

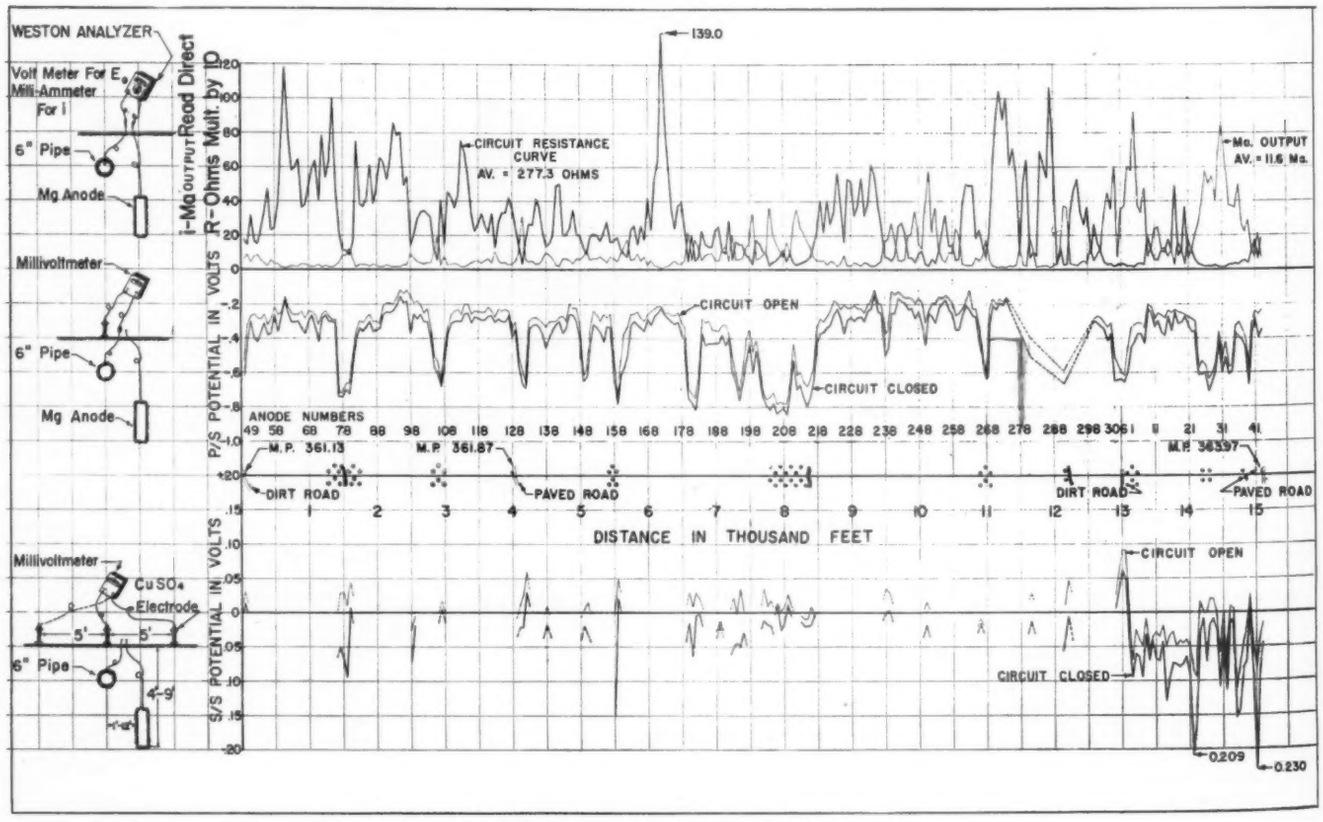
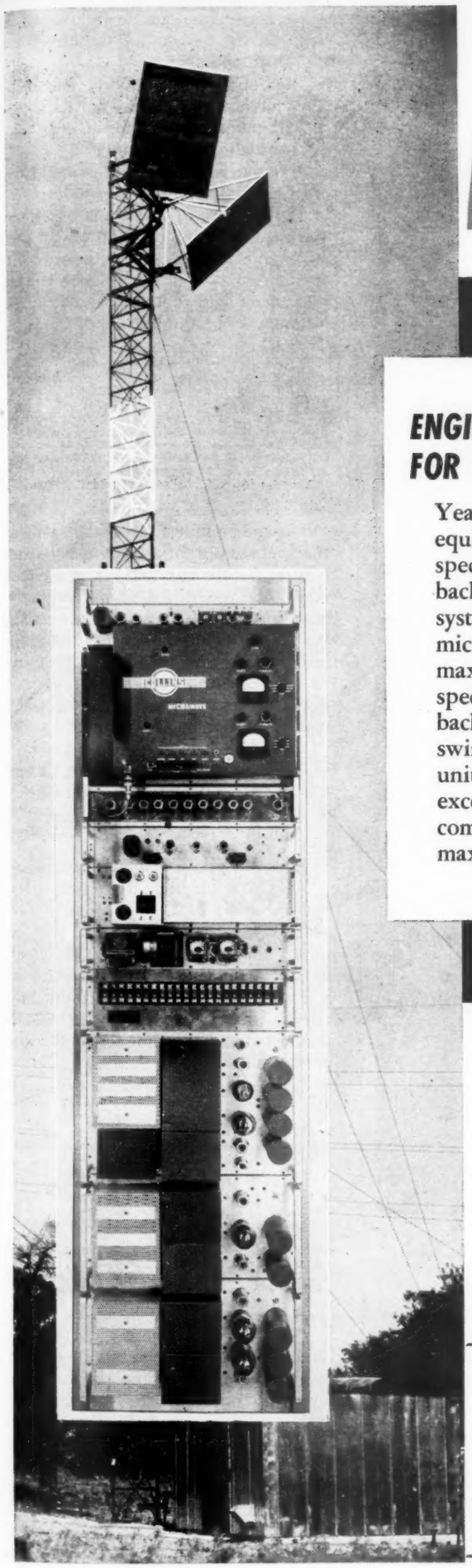


FIG. 2. Magnesium anode test data.



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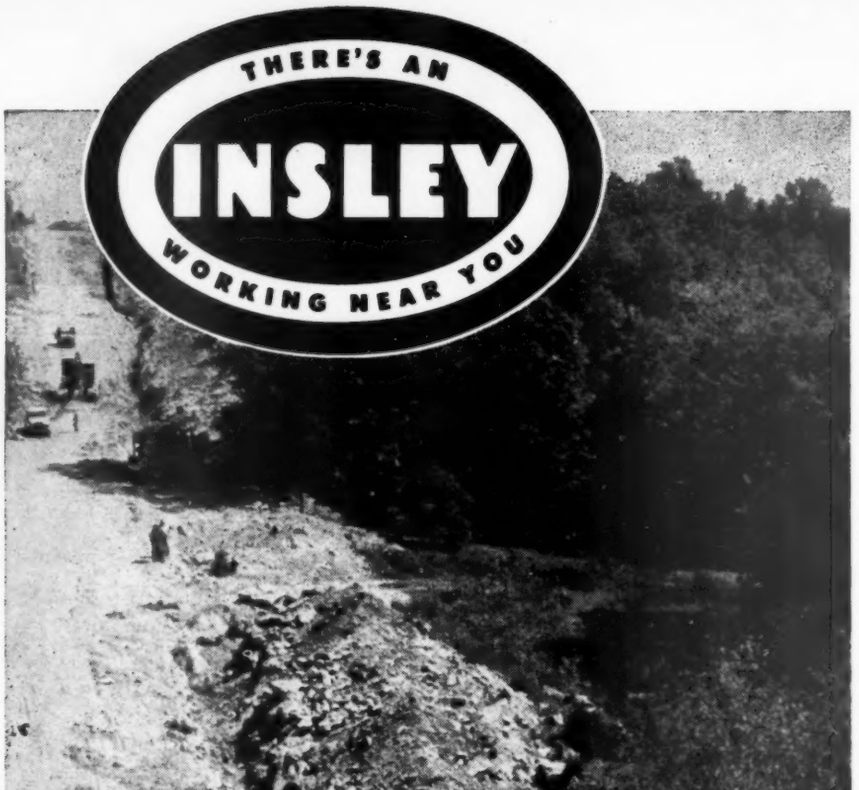

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least detrimental to anode output as seen on the curve. For the entire test of 301 anodes:

Maximum anode output was 92 milliamps from No. 5.

Minimum anode output was .9 milliamps from No. 172.

Average anode output was 11.6 milliamps from 301 anodes.

For anodes 1-43 only, soil samples were taken from the bottom of each hole and given a soil box resistivity test. These data appear to be in general agreement with output and circuit resistance. For example;

Anode	Ma	Resistance Calc.	Resistance Megger	Resistivity ohms/cc
5	92.0	14.4	11.8	2,160
12	25.0	53.7	52.0	40,000
17	2.6	490.0	420.0	180,000

Soil resistivity test for 1 to 43 averaged 24,000 ohms per cc.
Anode outputs for 1 to 43 averaged 32.0 Ma
Calc. circuit resistances for 1 to 43 averaged 78.4 ohms
Megger resistances for 1 to 43 averaged 68.6 ohms

For the complete test of 301 anodes, the average output as previously stated was 11.6 Ma and the average circuit resistance was 277.3 ohms, hence we may estimate the average soil resistivity (in anode hole bottoms) for the entire test to be either inversely proportional to anode output or directly proportional to circuit resistance in which cases we arrive at;

$$\frac{32}{11.6} \times 24{,}000 = 66{,}200 \text{ ohm/cc and}$$

$$\frac{277.3}{78.4} \times 24{,}000 = 85{,}000 \text{ ohm/cc}$$

Average of above = 75,000 ohms/cc.

As anode depths are estimated to average 6 to 8 ft, and resistivity decreases with depth as a rule, it is believed that at pipe depths the figure will average close to 100,000 ohms/cc.

From the P/S (pipe-to-soil) potential curves (heavy line curve for anodes connected and light line for anodes disconnected) we note;

	Anodes	Disc. volts	Conn. volts	(dE) volts	Output Ma
1. Min. P/S potential..	#263	.119	.230	.111	2.6
2. Max. P/S potential.	#206,	.780	.84,	.06,	15,
	208,	.780	.803,	.023,	7.5,
	209	.780	.845	.065	16
3. Min diff...	#267	.508	.513	.005	8.2
4. Max. diff .	#28	.155	.215	.215	55.0
5. Av. diff....	301 anodes			.058	11.6

6. From anodes #276-#299; — P/S data were taken only at anodic spots.
7. In 13 out of 16 locations where the curve dips below .6v indicating a possible anodic spot, the strip map shows either a creek, marsh, or road crossing.

The soil-to-soil potential curves were obtained by plotting points that represent the average of the two readings taken on opposite sides of the pipe. Plus readings are obtained when the electrode over the pipe was at the higher potential and negative readings conversely. Curves are shown with and without anodes connected. As noted, this test was made for every anode from 1 to 43, after which, to save time,

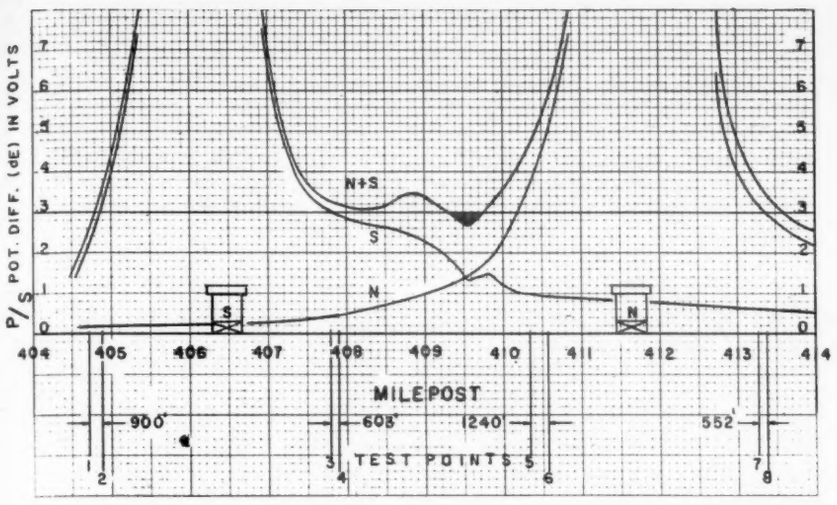

FIG. 3. Rectifier test data.

it was made only when an anodic condition was indicated by a quick check.

We note that each of the 16 points mentioned on the P/S curve is also indicated as anodic on the S/S (soil-to-soil) curve with the one exception of No. 268, and there are 7 apparent anodic points in addition which are detected by this test, making a total of 23. Additional testing *between* anodes near No. 268 might reveal an anodic area. A near-anodic point is at No. 266.

The important observation we make is that in 10 of the 23 cases the anodes fail to suppress the anodic condition in spite of the fact that measurements were taken at the anode location where potentials and currents are a maximum!

Of the remaining 13 cases where the anodic condition was suppressed *opposite* the anode, we can assume on the basis of test data not given here, that a sizable percentage of these locations *between* anodes are still unsuppressed!

Dotted lines were used on the soil-to-soil potential curves to indicate that test showed a cathodic condition at the adjacent anode location, however, it should be remembered, in view of the midway test mentioned above that additional test points would change the shape of these curves to give greater anodic area under the curve.

Estimated cost of protection using magnesium anodes

A. Actual test installation —inadequate protection 50 ft spacing	
Crew overhead..... (Includes wages, living expenses, equip. oper., maint. and Dep.)	$ 150.00/day
Cost per anode=$10 and Average anodes per day 12.55 at $10 anode.....	125.50/day
Total.....	$ 275.50/day
Job total for 24 days at $275.50....	$ 6,612.00
Cost per mile for 2.84 miles.....	$ 2,330.00
Cost per mile per year (10 year life)	$ 233.00
B. Solid protection method assuming additional tests showed 25 ft spacing adequate;	
Crew overhead.....	$ 150.00/day
Assume increase to 20 anodes per day at $10.....	$ 200.00
Total.....	$ 350.00/da
Job total for 2.84 miles at 500 ft per day or 30 days.....	$10,500.00
Cost per mile for 2.84 miles.....	$ 3,700.00
Cost per mile per year (10 year life).	$ 370.00
C. Spot protection method — placing anodes every 25 ft across anodic areas only as determined by soil/soil potential test;	
Normal crew overhead.....	$ 150.00/day
Extra engineering overhead for anode locating (2 men).....	$ 35.00/day
Assume 18 anodes per day at $10...	$ 180.00
	$ 365.00/day
Job total: 22 anodic spots involve approx. 3800 ft and would require at 25 ft spacing 152 anodes.	
At 18/day a total of 8.45 days at $365 per day.....	$ 3,085.00
Cost per mile for 2.84 miles	$ 1,086.00
Cost per mile per year (10 year life).....	$ 108.60

Of further interest is the fact that the two anodes, Nos. 5 and 31 having the greatest outputs, 92 and 84 Ma, respectively, are not in anodic areas, though the soil resistivity tests of 2160 and 4780 ohm per cc are phenomenally low for these depths in Georgia. We believe these low resistance pockets are few.

A spot check of ten anodes was made approximately three weeks after installation to determine change in output. Four had decreased, five increased, and one remained the same. The net effect was a 7½ per cent increase, consequently the 11.6 average shown becomes 12.5 ma. and the .135 ma/sq ft density becomes .145. This correction was not applied to the final data shown on Fig. 2 due to a similar small correction of rectifier densities.

Rectifier Test Data

This test was conducted to determine how the minimum and average current densities due to a rectifier system of cathodic protection would compare with the minimum and average densities produced by magnesium anodes. We were fortunate in having two units at mile posts 406.48 and 411.64 approximately 46 miles north of the magnesium anode test and lying in similar soil so that comparative tests could be made. Whereas rectifier units south of Atlanta

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obtain a mile of protection for about 3 amperes, above Atlanta it appears that 10 amperes or so per mile are necessary to obtain protection using the remote electrode criterion.

In using this criterion, we first install an interrupter in the a-c supply of the rectifier to enable observation of the difference in P/S potential caused by the on and off positions of the unit. Next we estimate, from previous experience, the location of the point at which the difference will amount to .3 v and proceed to take a measurement at that point.

If the difference, dE, is less than .3 v we take another reading closer to the unit, preferably a little greater than dE = .3, and then interpolate (on a straight line basis for short distances) for the exact dE = .3 point, which is designated as the full protection point. If the difference, dE, is greater than .3 v we take another reading further from the unit. The procedure used at each pair of test points was the same, hence only points 1 and 2 need be described as:

At Point 1 (Fig. 3), pipe-to-soil potentials, both local and remote, were taken with the unit on and off, and the differences obtained. Remote P/S differences are plotted. Next, a long lines test to determine direction and magnitude of the currents in the line with the rectifier on and off was made. Plus values indicate northward current flow, and minus, southward (See Table 1). A model M1 Weston voltmeter, in connection with a bridge circuit to insure elimination of poor probe rod contacts with the pipe, was used to find the millivolt drop over a convenient length of pipe, 75-ft over 6-in. pipe, giving adequate deflection of the needle on a 10-mv scale.

Meter Calibration

Calibration of the millivoltmeter was accomplished by passing 1-amp through a calibrating circuit consisting of the pipe, an outer set of rods, a rheostat, ammeter, lead wires, and hot shot battery, and noting the deflection of the millivoltmeter. We note that calibrating factors varied from 0 to 5 per cent when considering all eight test points, depending on whether the calibration was made with the rectifier on or off. Factors were determined for both conditions, eliminating possibility of error.

In arriving at dI_1 and dI_2, the differences due to the "on" and "off" rectifier positions were of course taken with the calibrating current off. We note, however, that the differences taken with the calibrating current on are practically the same, varying from zero for test point 1 to less than 2 per cent for point 8, the remaining six points running between these limits.

Test point 2 procedure is the same as for point 1, except that the location is chosen closer to the unit and above dE = .3 v, so that we may accurately estimate the .3 location. In this case, dE was .338 v, dE for point 1 was .212, and their average .275, as shown. Fig. D illustrates the method used at a test point to first calibrate, then obtain data for computing current density.

Knowing the lineal feet of pipe between points 1 and 2, and the size of the pipe, (6-in.) we find the pipe area, 1557 sq ft, as the product of 1.73 sq ft per lineal foot, and 900 lineal feet.

The amount of current due to the rectifier at point one, dI_2, subtracted from the current flowing at point two due to the rectifier, dI_1 is 3.34 — 3.07 = .27 amps, or 270 milliamps.

This net pickup of current occurring over 1557 sq ft of pipe results in a current density of .174 ma per sq ft.

Density Tests

This is called the minimum protective current density because it is the density existing at one of the extreme outer edges of the protected distance. Similar density tests, if conducted at points progressively closer to the unit would be expected to show increasing densities. Although our criterion of protection is dE = .3 and the average dE is .275 for the first pair of test points, a corresponding correction in current density is justifiable; however, the overall average dE for all four

TABLE 1.

Pipe to Soil Potential Test Data					Long Lines Test Data								
Test number	Rectifier	Local P/S in volts	Remote P/S in volts	Average remote de	Rectifier	One amp Calibrating current	Millivolts	Calibrating factor	Amps	Linear ft of pipe	Pipe area (1.73xlin ft) in sq ft	$dI_1 - dI_2$ in milliamps	Current density dI_1-dI_2/area
					Rectifier M.P. 406.48								
M.P. 404.72	On	0.453	0.560		On	Yes	+3.52	1.39	+4.89				
	Off	0.357	0.348		Off	Yes	+1.31	1.39	+1.82				
1	de	0.096	0.212		On	No	+2.80	1.39	+3.89				
					Off	No	+0.59	1.39	+0.82				
					dI_2				3.07				
M.P. 404.89	On	0.552	0.808		On	Yes	+3.68	1.409	+5.20				
	Off	0.495	0.470		Off	Yes	+1.33	1.390	+1.84				
2	de	0.057	0.338		On	No	+2.97	1.409	+4.19				
					Off	No	+0.61	1.390	+0.85				
				0.275	dI_1				3.34	900	1557	0.27×10^3	0.174
M.P. 407.80	On	0.340	0.728		On	Yes	−2.37	1.409	−3.34				
3	Off	0.272	0.428		Off	Yes	+0.97	1.335	+1.295				
	de	0.068	0.300		On	No	−3.08	1.409	−4.36				
					Off	No	+0.22	1.335	+0.294				
					dI_1				4.654				
M.P. 407.91	On	0.470	0.676		On	Yes	−2.00	1.317	−2.63				
4	Off	0.423	0.423		Off	Yes	+1.12	1.350	+1.51				
	de	0.047	0.253		On	No	−2.76	1.317	−3.64				
					Off	No	+0.38	1.350	+0.514				
				0.277	dI_2				4.154	603	1039	0.50×10^3	0.482
					Rectifier M.P. 411.64								
M.P. 410.34	On	0.380	0.868		On	Yes	+0.750	1.250	+0.938				
	Off	0.330	0.580		Off	Yes	−1.88	1.203	+2.270				
5	de	0.050	0.288		On	No	+1.55	1.250	+1.938				
					Off	No	−1.05	1.203	−1.264				
					dI_2				3.202				
M.P. 410.57	On	0.740	0.935		On	Yes	+3.57	1.429	+5.12				
	Off	0.703	0.625		Off	Yes	+0.78	1.450	+1.13				
6	de	0.037	0.310		On	No	+2.87	1.429	+4.10				
					Off	No	+0.09	1.450	+0.13				
				0.299	dI_1				3.97	1240	2145	0.768×10^3	0.358
M.P. 413.27	On	0.292	0.635		On	Yes	−4.49	0.877	−3.940				
	Off	0.269	0.329		Off	Yes	−2.10	0.855	−1.793				
7	de	0.023	0.306		On	No	−3.35	0.877	−2.930				
					Off	No	−0.93	0.855	−0.795				
					dI_1				2.135				
M.P. 413.38	On	0.400	0.668		On	Yes	−2.75	1.317	−3.625				
	Off	0.298	0.345		Off	Yes	−1.29	1.281	−1.635				
8	de	0.102	0.323		On	No	−1.99	1.317	−2.610				
					Off	No	−0.51	1.281	−0.655				
				0.315	dI_2				1.955	552	955	0.18×10^3	0.189

NOTE: (+) Sign indicates current flow from south to north. (−) Sign indicates the opposite.

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pairs of test points is .2915, and assuming a straight line relationship, would increase the average minimum current density approximately 3 per cent or from .301 to .31 ma per sq ft.

In the interests of simplification, this correction was not made in the tables shown; furthermore, this correction nearly offsets the small magnesium anode correction mentioned previously. The chief value of the P/S potential test data shown in Table 1 is to assure us that the long lines test data, from which current densities were calculated, were made at the proper locations; i.e., at approximately the .3 v difference points. Table 3, entitled spread test and current requirement data, is a summation of rectifier spread test data of Table 2, pipe-to-soil and long lines data from Table 1, and comparative magnesium anode data from Fig. 2.

TABLE 2.

	M.P. 404.72		M.P. 404.89		M.P. 407.75		M.P. 408.87		M.P. 409.55	
	P/S Local	P/S Remote	P/S Local	P/S Remote	P/S Local	P/S Remote	P/S Local	P/S Remote	P/S Local	P/S Remote
Both on	.453	.560	.620	.865	.332	.742	.550	.655	.65	.805
North only	.357	.348		.532		.440		.410	.64	.681
South only				.841	.278	.719		.550	.63+	.678
Both off			.575	.515	.275	.410	.535	.310	.63	.540
dE total			.045	.350	.057	.332	.015	.345	.02	.265
dE north	—	—		.017	0	.030		.100	.01	.141
dE south	.096	.212		.326	.003	.309		.240	.005 est.	.138

	M.P. 409.83		M.P. 410.11		M.P. 413.02		M.P. 413.27	
	P/S Local	P/S Remote	P/S Local	P/S Remote	P/S Local	P/S Remote	P/S Local	P/S Remote
Both on	.458	.84		.960	.665	.838	.339	.662
North only	.450	.70		.850		.760		.610
South only	.437+	.67		.680		.440		.250
Both off	.437	.52		.572	.607	.361	.320	.291
dE total	.021	.32		.388	.058	.477	.019	.371
dE north	.013	.18		.278		.399		.319
dE south	.0005 est.	.15		.108		.079		.059

Period on north interrupter ON — ¼ minute: Off — ¾ minute
Period on south interrupter ON — 1 minute: Off — 2 minutes

Interrupters Used

The P/S potential data of Table 2 were obtained by operating interrupters simultaneously in each of the two rectifiers, and observing the potential differences at nine different locations due to each unit separately as well as both at once. This was made possible by having a different cycle for each interrupter. Fifteen seconds on and 45 seconds off were used for the north unit, and 60 seconds on and 120 seconds off for the south unit. The obvious advantage of this method in addition to the great time saving effected, is the elimination of inaccuracies due to changing probe rod contact resistances when made a second time, changes in potential due to varying rectifier outputs on different days or due to changing soil conditions, and changes in P/S potentials due to rains between readings, etc.

Although P/S potential test data in Table 1 were obtained in conjunction with long lines test data to determine minimum current densities, P/S data of Table 2 were obtained to more completely determine the protective spread of each rectifier as well as both together, and to enable plotting of spread test curves shown in Fig. 3.

The familiar setup for taking local or remote P/S potentials is illustrated in Fig. 5.

Spillover Currents

From Table 3 we note that the limits of protection, lineal miles, and pipe area protected are obtained for each

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unit. Then, in lieu of charging up the entire rectifier current output to the protection of this area, as is done for a rough approximation of average current density, we deduct from the full output, those currents fluxing into the pipe beyond the protected zone limits which may be called spillover currents. These are very important in the design of a system of rectifiers since the potentials they produce, while less than $dE = .3$, nevertheless are additive with similar small potentials from adjacent units and result in greater spacing between units.

The magnitude of these "spillover currents" is 15.65 per cent of the north unit output and 26.4 per cent of the south unit output. By taking these currents into consideration in determining the net or correct current influx within protected limits, we will arrive at a smaller figure for average current density than if they were neglected. In spite of this, the average density is 6.4 times greater than that obtained with magnesium anodes and minimum current density at the extremities is 2.23 times magnesium anode average.

If we divide the output of the poorest anode, .9 ma, by the area of the 50 ft of pipe assigned to it for protection, we arrive at a minimum anode density of .0104 ma per sq ft, which is about 6 per cent of the minimum rectifier density found on the south side of the south unit.

We see a shaded area approximately ½-mile in extent on the total spread curve of Fig. 3, which means that full protection is not being provided. This area will be eliminated when the output of these units is increased.

Estimated cost of protection using rectifiers

Crew overhead: (wages-daily, expense-equip. op/maint., and dep.	$ 150.00/day
Average inst. of 12 days at $150	1,800.00
Average graphite anodes per ground bed: 30 at $50	$ 1,500.00
(Includes cable, connectors, tape, backfill)	
Rectifier and installation	$ 500.00
Easement	$ 200.00
Total rectifier installation cost	$ 4,000.00
Rectifier installation cost	$ 4,000.00
Power cost at $46/mo. or $552/yr. over a 20 year period (estimated 20 year life)	$11,040.00
Estimated ground bed maintenance over 20 yr period	$ 1,000.00
Total 20 year cost	$16,040.00
Cost per year	$ 802.00
Average miles of pipe protected by each of two units working in conjunction (see spread curve on Fig. 3)	3.9*
Present cost per mile per year (20 year life) for two units only — working in conjunction	$ 205.64

* This figure will be still greater when rectifiers are installed on the far sides of the two existing units, since P/S potentials are additive and spillover currents beyond points of full protection will add to give full protective potentials. In this case, estimated mileage per unit will become 4.75 miles thereby lowering the:

Cost per mile per year to ..... $ 169.00

This is 45.7 per cent of the $370.00 per mi per yr cost of full protection with magnesium anodes, assuming we could get full protection with 25 ft spacing, and even then the prospects of anode current density reaching the minimum rectifier current density are dim.

Summary

As the test was performed, rectifiers have an average current density advantage over anodes of 6.4 to 1.

A rectifier system has a cost advantage over anodes, as installed on 50-ft centers, of

$$\frac{(\$\ 233)}{(\$\ 169)} \text{ or } 1.38 \text{ to } 1.$$

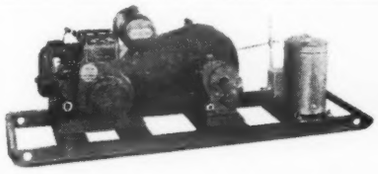
Taken together, we may say that rectifiers show an overall cathodic advantage over anodes of 8.83 to 1.

As anodes on 50-ft centers proved inadequate, the above statements become irrelevant. Let us repeat these statements on the basis of 25-ft spacing, which we shall assume is adequate.

Rectifiers will have an average current density advantage over anodes of 3.2 to 1 (The minimum rectifier density will still be greater than the average anode density).

A rectifier system would have a cost advantage over an anode system on a 25-ft spacing basis of $\frac{370}{164}$ or 2.14 and taken together we may say that rectifiers show an overall cathodic advantage over anodes of 7.01 to 1.

A vital part of any system as expensive and critical as a cathodic protection system is the means by which management can be assured of its proper



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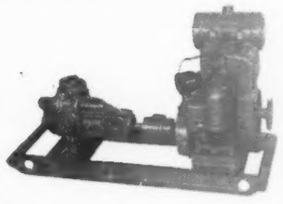

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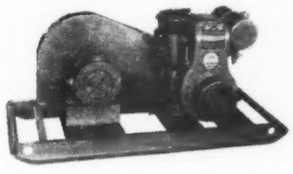

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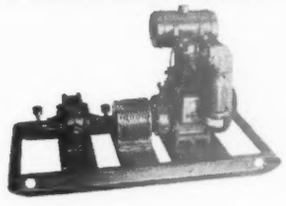

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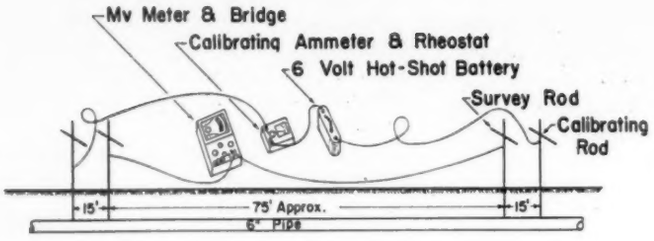

FIG. 4. Calibration and survey instrument setup for long lines test data.

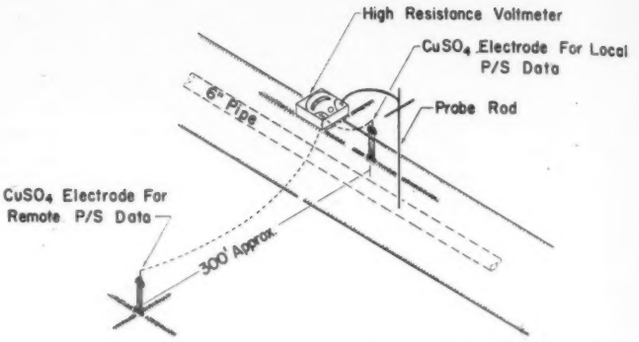

FIG. 5. Instrument setup for pipe-to-soil potential test data.

and continuing operation. In this respect a rectifier system is far superior to an anode system due to the ease with which excellent supervision may be maintained compared with the costly, time consuming, operation of checking each anode output.

Linewalkers and pump station personnel read volts, amps, KWH, and meter RPM approximately once each week and teletype this information to the chief dispatcher who consolidates the data in a monthly report. By scanning this report, troubles can be quickly detected and diagnosed, and the electrician or maintenance crew dispatched to the job. Restoration of initial output assures us that the same amount of pipe is once again under protection. On the contrary, after an anode is once installed, one never knows whether or when its output changes unless it is uncovered and measured, an uneconomic procedure even if carried out annually.

Proper Testing

In order to properly test each anode of a spot protection system, it is estimated that an engineer and two pipeliners with a truck could test about 50 anodes per day. Over our 2.84 mile test, 152 anodes were estimated as required on a spot protection basis. This is 53.5 per mile or 5350 for the 100 miles of pipe yet to be protected. The checking crew would require 107 days, or approximately five months, at a total cost of $7000, or $70 per mile.

If this survey were conducted once a year it would run the spot protection system cost to $178.60 per mile per year, which is greater than the full protection rectifier system cost and still does not begin to provide a comparable degree of supervisory control.

Due to the necessity for close spacing of anodes, such a system again breaks down when highways, streams, and other inaccessible locations are encountered.

Although it is recognized that magnesium anodes and rectifiers are both bonafied methods of corrosion mitigation, it is emphasized that for solid main line protection, anodes are restricted to the low resistance soils while rectifiers become more effective as soil resistivity increases, providing reasonably low ground bed resistances can be obtained.

This latter point is important since power costs for a given ampere output, are proportional to ground bed resistance. It is also important to note in this case that while average resistivities are very high (estimated 75,000 ohm-cm at anode depths) resulting in an 11.6 ma output per anode, that a rectifier ground bed system would be so located as to take advantage of the lowest resistivity spots after which graphite ground bed anodes would be installed in holes of optimum depths, as determined by soil box resistivity tests made by the field engineer in charge of the drilling crew.

Where short isolated spots need protection and a rectifier installation is not justified, ribbon is recommended, with strips installed on each side of the pipe at anodic locations.

In November, 1953, the 120 mile (6-in. pipe) rectifier system from Atlanta to Chattanooga was completed with 14 units designed on the same basis as the 25 (8-in. pipe) rectifier system from St. Joe to Atlanta, a distance of 350 miles. We note that the latter system averaged 14 miles per unit and the former 8.58 miles per unit, indicating that soil resistivities above Atlanta are roughly 61 per cent of those below. It is interesting to observe that use of the remote criterion automatically takes the lower resistivity soil into account.

Leak record experience with the remote criterion design shows completion of the 25 unit system in October, 1952, one leak each in January, February and March of 1953, after which no leaks occurred until January, 1954, a 10-month period.

As soil resistivities at pipe depth become less, rectifier protective spreads decrease for a given output, which tends to raise the cost of protection, however, lower ground bed resistances should also be obtainable, which tends to lower the cost of protection.

By the same token anode outputs increase but more output is needed.

There are, no doubt, soil conditions that will allow the use of either anodes or rectifiers with equal cost. Then we are all familiar with the low resistivity soils where anodes are the obvious economic answer.

The preceding information has been presented as a practical method for determining whether existing soil conditions lie in the anode or rectifier zone.

★ ★ ★

TABLE 3.

Spread Test and Current Requirement Data	Rectifier		Rectifier	
By interpolation of P/S remote potential test data;	MP 406.48		MP 411.64	
dE = .30 is estimated on the north to be at milepost	407.8		413.33	
dE = .30 is estimated on the south to be at milepost	404.8		410.17	
Independent protection from each unit in miles	3.0		3.16	
Protected 6 in. pipe area from each unit in sq ft (9134 sq ft/mi)	27,402		28,863	
By interpolation of long lines "amps" test data;				
Current influx to pipe beyond north full protection point is	4.65		1.31	
Current influx to pipe beyond south full protection point is	3.26		3.62	
Total influx to pipe beyond north and south full protection points is	7.91		4.93	
Total rectifier current output	30.0		31.5	
Total influx beyond protected zone as % of rectifier output	26.40		15.65	
Net influx within protected zone is	22.09		26.57	
Average current density required for protection: ma/sq ft	22090/27402		26570/28863	
	.806		.920	
Average of both rectifiers		.863		
Minimum current densities for protection at limit points: N	.482		.189	
(from last column Long Lines Test Data) S	.174		.358	
Average	.328		.2735	
Minimum averaged for both rectifiers		.301		
From drawing B number of magnesium anodes installed	301			
Total current output from anodes in milliamperes	3493.55			
Average output per anode in milliamperes	11.6			
Total miles of pipe in test from MP 361.13 to 363.97	2.84			
Total area of pipe at 9134 sq ft per mile	25,941			
Average current density of anodes: ma/sq ft	.135			
Average rectifier current density as % of average anode curr. density	640%			
Minimum rectifier current density as % of average anode curr. density	223%			

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On the job shown above, coating and wrapping rates up to 17,000 feet per day were reported. This remarkable record is a tribute to Transhield's special tear-free reinforcement. This reinforcement is accomplished through the use of continuous glass yarns, parallel spaced on ¼" centers.

Designed for average soil conditions, Transhield is a light-weight felt composed of coal-tar saturated asbestos. This time-tested material assures an efficient barrier between pipe line enamels and earth loads . . . soil stresses.

As an outer sheath to retard cold flow, Transhield takes advantage of the full thickness of the enamel coating—working effectively toward preserving a continuous film of enamel on the pipe line.

Long-Length Rolls—Available in 800-ft. rolls (14" O.D., 2" I.D.) for traveling power-driven coating and wrapping machines. Other lengths can be furnished to suit your method of application. Widths are from 2" to 36".

Johns-Manville has developed three wrapping materials for pipe line protection:

J-M 15-lb. Asbestos Pipe Line Felt (perforated or unperforated)—for severe soil conditions.

J-M Transhield Asbestos Pipe Line Felt—for average soil conditions.

J-M Trantex polyvinyl pressure sensitive tape—for pipe line corrosion protection where ease of application is important such as when coating field joints of mill-wrapped pipe or making emergency pipe line repairs.

For further information write Oil Industry Department Johns-Manville, Box 60, New York 16, N. Y.

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Johns-Manville ASBESTOS PIPE LINE FELT

XUM

"KING-SIZED PUSH JOBS"

Building pipe lines in Louisiana's marshlands using long sections of jointed pipe isn't new; unusual, though, are continuous pushes of 10 or more miles of pipe; here's how Interstate Oil Pipe Line Company did two such jobs

F. E. MILLER*

AMONG the unusual construction techniques used during the laying of Interstate Oil Pipe Line Company's new 16-in. crude oil trunk line between Raceland and Baton Rouge, Louisiana, were two "king-sized" push jobs measuring 10 and 14 miles, respectively, in length.

This method of welding up long sections of pipe line on a ridge of high ground and pushing it out into the swamp as new joints are added is a common practice in marshlands such as are found in coastal Louisiana. Such a seemingly simple procedure becomes more complex, however, when one continuous push involves 10 or more miles of pipe.

Additional problems were injected into the Interstate Oil Pipe Line project by the fact that the pushed sections crossed several canals in the area that is busy with land waterways traffic.

The new line was part of a 59.5 mile replacement and relocation project on Interstate's Raceland (South Louisiana) district system. Built of 16-in. pipe, the new line replaced existing 8 and 10-in. lines between Raceland, in LaFourche Parish, and Interstate's Anchorage Terminal, across the Mississippi River from Baton Rouge. Contractor on the job was L. E. Farley, Inc., Houston, Texas.

The 14-mile push began at a point east of Thibodeaux, near Chackbay, and extended northwestward to a point three miles south of Interstate's Bayou LaFourche crossing at Belle Rose. The 10-mile push started at Choctaw Road and extended south and east to a point about three and a half miles north of Raceland.

In preparation for the pushes, ditching was done by regular draglines that were supported on heavy timber mats. Ditches were made wide and deep enough to be used by small motor boats bringing in men, fuel, supplies, etc.

At canal or bayou crossing points, banks were cut back and bottoms ditched out to a gradual slope. This was done so that the completed line, when filled with water, would sag into place without requiring any line bends.

Four Pipe Sizes Used

Pipe for the project came in four different wall thicknesses: 3/8, 5/16, 9/32, and 1/4-in. Heaviest wall sections were laid on the high pressure end of the finished line, nearest the pump station at Raceland. This pipe was yard coated in advance. The coating included a hot application of coal tar enamel reinforced by an imbedded fiber glass wrap, with an asphalt impregnated felt wrapping over the ena-

*Interstate Oil Pipe Line Company, Shreveport, Louisiana.

EXCLUSIVE

FIG. 1.

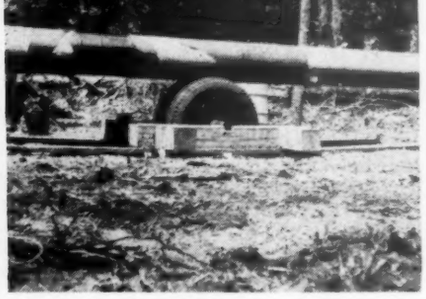

FIG. 2.

FIG. 3.

FIG. 1. Completed part of 16-in. pipe line on 10-mile push, sealed at end to hold air, was floated into place through a water filled ditch. As more joints were welded on to the line, behind the camera, the completed line was pushed further up the ditch.

FIG. 2. Close-up of one of the welding dollies used to support the line while being assembled and pushed into the ditch. Smoothed truck tire treads prevent damage to protective coating and pipe wrapping. Bare pipe around weld, left of tire, has been primed preparatory to a hot patch application of coal tar enamel and asphalt impregnated felt wrapping. Pipe for the line was coated in the yard.

FIG. 3. General view of assembly line type construction spread used on 10-mile push job shows three sheltered welding stations used. Stringer beads were applied at the first station, and welds were completed at the second or third. Long joints of pipe, 45 to 46 ft in length, helped reduce the number of welds.

FIG. 4.

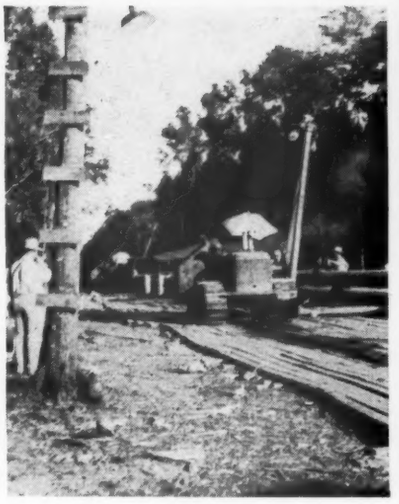

FIG. 5.

FIG. 6.

FIG. 4. Close-up of one of the three welding stations. Note heavy planking that was necessary to keep equipment from bogging down in the marshy land.

FIG. 5. Joint of 16-in. is being lifted into place for welding on to end of completed line. Note the light rigged on the pole at left in photo. This was used during second-shift construction.

FIG. 6. Joints tack welded to line at left moved to right as push progressed. Successive operations performed along the assembly line type spread included stringer weld, finished weld, and protective coating, and wrapping weld area.

mel. The yard coated pipe was also given an outer wrapping of Kraft paper at the yard for additional protection. Long joints of pipe, 45 and 46 ft in length, were used to reduce the number of welds which would have to be made during the pushing operation.

With everything in readiness, the pushes were launched and work was carried out on an around-the-clock schedule. Two shifts were used during the pushes, and about a mile of line was laid per day, or about 130 welds during each 24-hour period.

Three welding stations, with two welders at each, comprised the assembly line type construction spread used on the pushes. The stringer beads were applied at the first station and the welds were completed at the second or third. Usually, two joints of pipe would be tack welded to the line by the first crew before a push was made. After the push, the second and third crews would finish those welds while the first crew was tacking on two more joints.

In addition to visual inspection, completed welds were checked by Gamma ray to the extent that full-time use of the Gamma ray equipment would permit. The completed sections were also pressure tested, using water at 1000 psi.

Supporting the line during construction were dollies fabricated from smooth treaded truck tires. As new joints were added, the completed line was moved out by a winch on a side boom tractor. The same tractor and winch served as a brake to stop the movement of the line at the end of the push.

Supplementing the tractor as motive power and brakes for the push was a winch mounted on a heavy timber framework that straddled the line on the push ramp. This winch was located between the last welding station and the point where the completed line entered the ditch. It could be used alone to start or stop the push, or it could be used in conjunction with the tractor to steady the line by applying a pull in the opposite direction from the one being exerted by the tractor.

Winch lines were attached to the pipe by special clamps that gripped the

FIG. 7.

FIG. 8.

FIG. 9.

FIG. 7. Winch line used to move completed pipe section is being attached with clamp which grips pipe at bare weld area to prevent clamp from damaging protective coating. Tractor at left usually provided both motive power and brakes for pushing line.

FIG. 8. Protective coating was applied to welded joints just before they reached the ditch.

FIG. 9. Protective coating on the pipe was tested with an electric "holiday" detector.

XUM

FIG. 10.

FIG. 11.

FIG. 10. General view of pipe yard set up just south of Plaquemine, Louisiana. Pipe was coated and wrapped here for both the 10 and 14-mile pushes. Coating included a primer, hot coal tar enamel reinforced by an imbedded fiber glass wrap, a wrapping of asphalt-impregnated felt and an outer wrap of kraft paper for added protection while pipe was being hauled to the job.

FIG. 11. Mounted on a framework straddling the pipe line, this winch was used to supplement the tractor normally used to start and stop the push. This winch could function alone, or could be used to steady the pipe line by applying a pull in the opposite direction from the one being exerted by the tractor.

pipe line at a bare weld area. This prevented the clamps from damaging the protective coating on the pipe. Hot patches of protective coating were applied further along the construction line after the clamps had been removed.

Precision Measurements Required

Once the end of the line began to move out into the ditch, some precise measurements were required. Some of the canal crossings required river weights to be applied to the line, and these had to be situated on the line so that they would be in proper position when the push was completed. By way of example, the first weights attached to the 14-mile push were for a crossing 13 miles away from the construction site.

During construction, a crew followed the head end of the line as it was pushed up the ditch. The crew's jobs were to see that the pipe stayed on course through the ditch, and to direct the pushing operation when the line reached a waterway crossing. Communication between this crew and the construction base was provided by mobile radio units.

Operation Was Smooth

In spite of the length of the pushes, and the many possible difficulties that could have been encountered, only one shut-down occurred. This was when the water level in the area rose above the top of the ditch so that there was no longer anything to keep the floating line on course. When the water level receded again after a brief period, construction activities were resumed.

One other push was required on the project, but it was a relatively minor matter of some three and a half miles. Some idea of the terrain may be gained, however, from the fact that almost half of the 59.5-mile section of 16-in. line had to be laid by this method. The balance of the route was through cane fields or through swampy areas that were dry and firm enough at the time for normal construction methods to be used.

Line Capacity Doubled

Completion of the new line provided a trunk line capacity of approximately 62,000 bbl per day. This is more than double the original line's 28,000 bbl per day capacity. For two years prior to construction, however, the capacity of the original system had been increased temporarily to 40,000 bbl per day by the installation of two intermediate booster stations and additional pumping equipment in the existing stations along this route. * * *

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Needed: Tons of Steel

The gas industry used approximately 1,725,000 tons of steel in 1952, principally in line pipe. The tonnage for 1953 was higher, since more miles of pipe were laid in 1953 than a year earlier. However, the gas industry estimates that it will require 7.3 million tons of steel pipe for its expansion program from 1953 through 1956. The major part of this tonnage will represent steel pipe of 16 inch diameter or larger. Approximately 5 million tons of steel will be required for the large diameter pipe.

longer lines

larger pipes

Control Problems?

more powerful driving units

unattended stations

WITH today's longer lines, larger pipes, more powerful driving units, and unattended stations, pipe-line installations must be precisely controlled. Many operators have proved that maximum efficiency is obtained when conditions are regulated by Taylor instruments specifically designed for their control.

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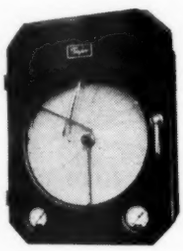

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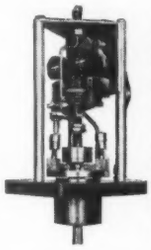

Taylor Pneumatic Speed Transmitter offers an accurate and efficient method of measurement and pneumatic transmission for the control of speed on compressors, pumps, or engines . . . or on applications where the process variable is equipment speed. **Convenient Direct Speed Readings** are recorded on a squareroot chart or scale. **Direct-Set Speed Feature:** The engine speed can be easily and quickly varied manually, by turning a knob on the receiver controller, or automatically by the Master Pressure Controller. **High Accuracy:** Output air pressure is proportional to the square of measured speed accurate to 0.03 psi. **Great Flexibility:** Only top speed needs to be determined. Selection of fly-weight speed 600 to 1500 rpm. Output air pressure of unit from zero to top speed produces an output air pressure of 3 to 15 psi.

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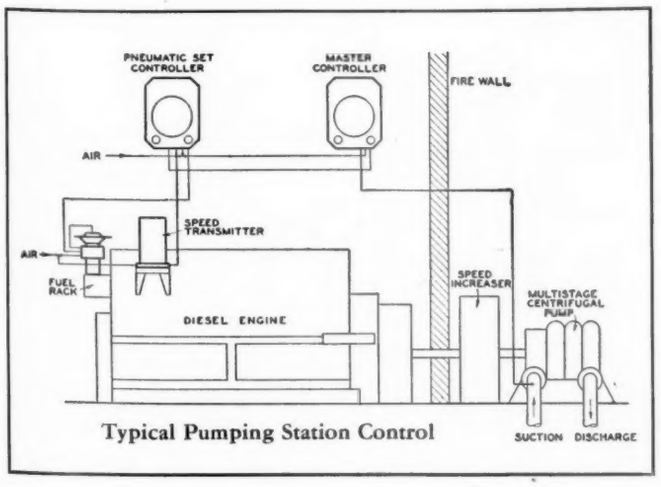

Typical Pumping Station Control

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H. S. DARBY

TO operate and maintain its thousands of miles of wholly-owned pipe lines — presently situated in 13 states and the District of Columbia — Sinclair Pipe Line Company must maintain a large fleet of motor vehicles, motor driven machinery, and heavy work equipment.

Despite the vast size of the pipe line system, the public is generally unaware of the extensive facilities and equipment that constitute the physical properties. Practically all of the pipe through which the oil is transported is buried underground, while pump stations, warehouses, garages, etc., as a rule, can be seen from the highways. The mobile equipment so necessary to our operations, although it is placed at intervals along the system, is, however, the one part of the physical facilities the traveling public most often sees.

The motor transportation departments of the pipe line industry always look upon the stationary pipe lines as being dependent for maintenance on mobile equipment. The complex truck and work equipment of today is far different from the horses and wagons and their team bosses, the skinners, and swampers, of 50 years ago. Today, the demand is for more efficient motor transportation equipment. This demand is reflected in the continuing efforts of manufacturers of work equipment to create more dependable and versatile products.

Operation and maintenance of an extensive pipe line system requires the strategic location of field personnel together with the necessary complement of this mobile work equipment.

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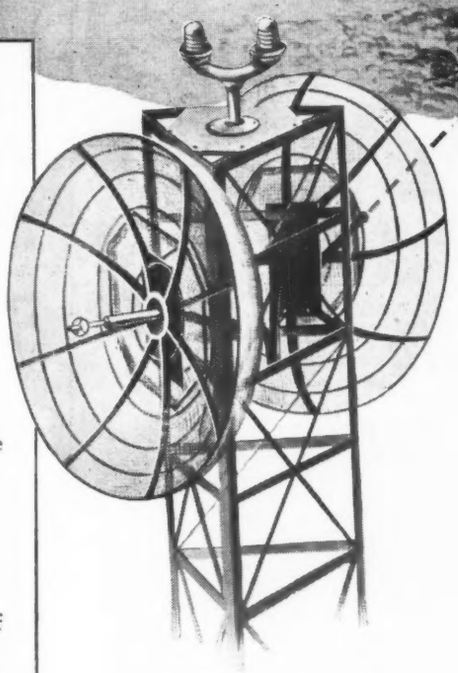

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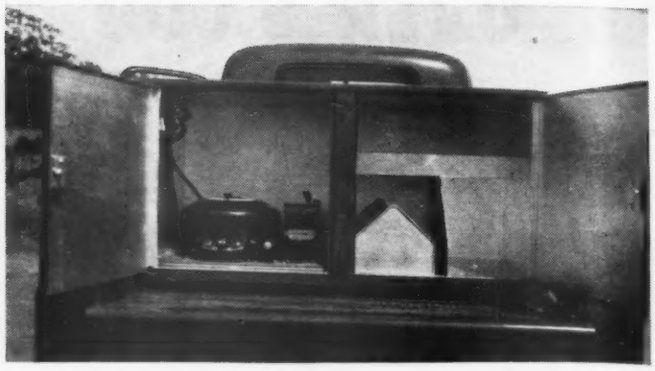
IT'S A FACT . . .

IT&T scientists conducted the *first* successful demonstration of voice communication via *microwave*, March 31, 1931, across the English Channel.

Gang truck with float trailer.



Rear view, gager's ½-ton truck, showing equipment compartment.

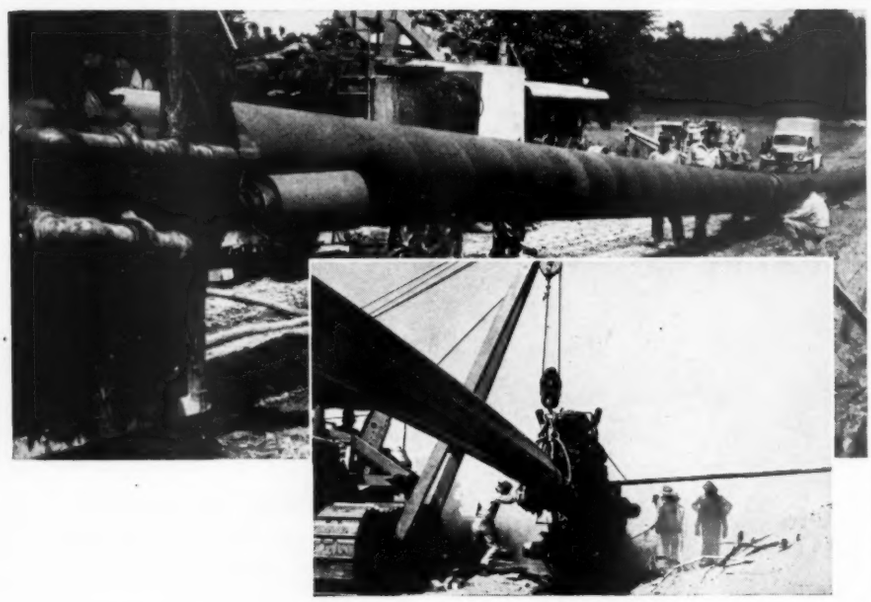
have been established as maintenance headquarters. Each has been fully equipped with ditchers, tractors, arc welders, air compressors, portable pump units, and the necessary trucks for the transportation of all emergency or maintenance equipment. The areas served by these maintenance headquarters vary, but never exceed 300 miles in length. In addition to headquarter maintenance base operations, the company has 58 other locations where it bases vehicles equipped with specialized devices for the maintenance of electrical, telegraph, radio, and microwave installations.

The latest compilation regarding Sinclair Pipe Line's company-owned motor vehicles assigned to 105 bases of operation reveals that an estimated total of 7,155,000 road miles were traveled during the 12-month period ending December 31, 1953. During the same period, mileage for rental automobiles on construction projects totaled 1,583,000 miles. Yearly total for all vehicles comes to 8,738,000 miles — equal to approximately 350 trips around the world.

Proper Maintenance Is Vital

If the operations of a pipe line company permitted the working of its mobile equipment in and out of a few terminals, as is possible in many kinds of business, fleet maintenance and handling problems would be comparatively simple. As it is, dependence must be placed upon many individual drivers and highly qualified mechanical personnel for inspection and repair services.

In contrast to conditions during the early days of pipelining, good highways now are plentiful; however, these vehicles seldom operate on highways. The rough terrain with which they have to contend — varying from the sands of western Kansas, through the rocky soil of the Osage, to the mountains of Wyoming — together with variations in climate, altitude, and soil conditions, requires that they possess physical qualities that permit them to operate at maximum efficiency in the particular



Mile after mile – to last for years

This line is being wrapped with RUBEROID pipe line asbestos felt over PITT-CHEM hot applied tar base coating. An S. D. Day man was on hand when these jobs were started to give his help and advice — part of the follow-up service you get when you "DEAL WITH DAY."

The ability of RUBEROID asbestos felt and PITT-CHEM. coal tar enamels to meet and withstand the severe requirements of pipe line service against corrosion adds years to the useful life of pipelines. Both of these products are stocked in Houston for immediate shipment.

Engineering counsel, literature and prices are furnished through our Houston office.

S. D. Day Company is National Distributor for The Ruberoid Company pipe line asbestos felt, and Gulf Coast Distributor for Pittsburgh Coke & Chemical Co. hot and cold applied coal tar coatings, and American Coating & Supply Company's fieldjointer.

The Pipeliner's Friend says,
"Formula 291 gives skin protection for those working where fumes may be toxic."

S. D. DAY COMPANY

1973 WEST GRAY HOUSTON, TEXAS PHONE JU-2431

How SUNRAY OIL boosts pipe line capacity 25%

Three years ago production skyrocketed at the Sunray Oil Corporation refineries in Duncan and Allen, Okla. Expansion throughout the system overloaded the 6-inch pipe line between the two cities. Bigger pipe was not available.

Sunray engineers hit on a cost-cutting solution—installed three electrically powered booster stations between regular pumping stations. They know that electric motors cost less to install . . . require little maintenance . . . are easily adapted to remote control circuits.

Then engineers selected an RCA 960-mc Microwave radio-relay system to effect complete remote control of the *"boosters"* from regular pumping stations. Microwave stations spaced miles apart proved cheaper to install and maintain than direct wire. And Microwave systems are virtually weatherproof.

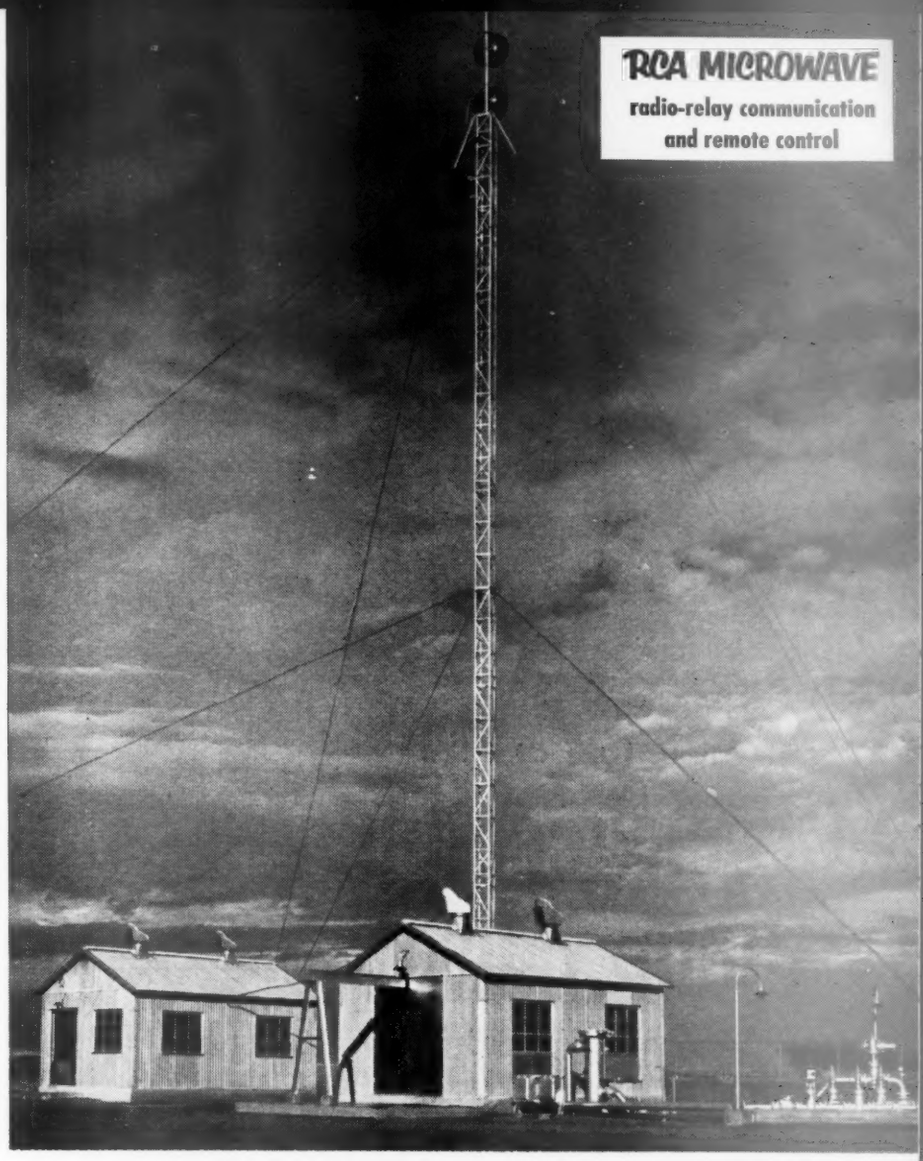
When the Sunray microwave-operated *"boosters"* were put in operation on January 31, 1952, *the pipe line's capacity immediately increased 25 per cent!*

RCA Microwave "beams" highly directional radio signals from station to station by "dish" antennas. Since 1946 RCA has installed many fully reliable Microwave systems, some over 1,000 miles long. *All have proved themselves in performance*—for utilities, government agencies, telegraph companies, turnpikes, as well as pipe lines.

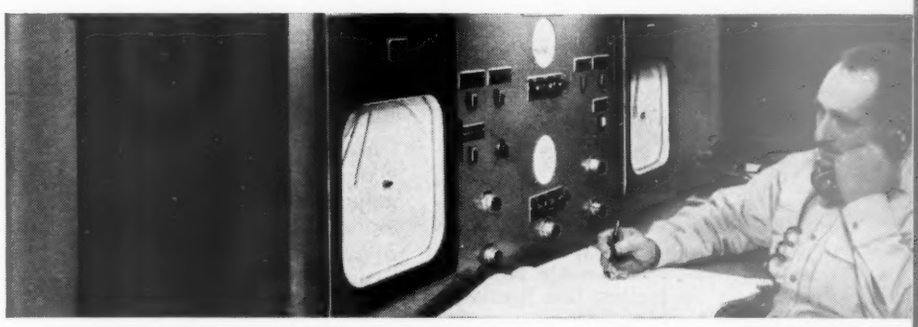
In addition to remote control and supervisory functions, RCA Microwave provides as many voice and teletype channels as you need—and does it with a minimum of frequency space. It employs readily available tubes and familiar circuits which are easy to service. It interconnects with your telephone lines and switchboards.

If you desire, RCA supervises survey, construction and installation—offers a complete single-source, single-responsibility service. And only RCA can provide the nationwide service facilities of the RCA Service Company.

For more information, mail the coupon ▶



Unattended booster station at Pernell, Okla. Radio-beam signals via RCA Microwave operate the booster by full remote control. Maintenance man inspects each station once every 24 hours.



Telemeter charts give continuous record of power and pressures at boosters. Operator remote-controls valves and pumps of booster stations. Signal lights indicate equipment failure and emergency generator operation. 2-way voice channel contacts maintenance personnel.

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COMMUNICATIONS EQUIPMENT CAMDEN, N. J.

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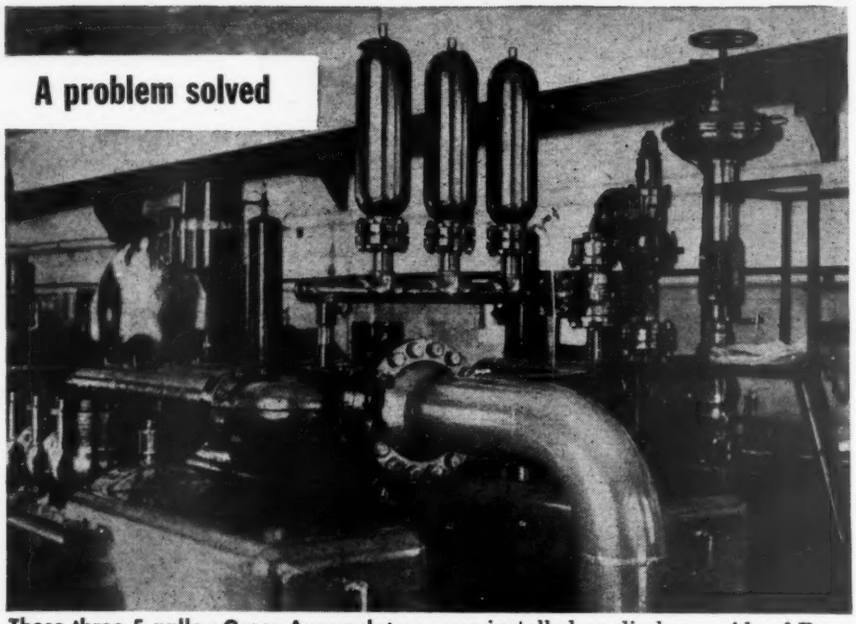
Without obligation on my part, please send me your free booklet on:
☐ A Booster Station Microwave System ☐ Pushbutton Operation of Boosters

Name_____ Title_____ Company_____

Address_____ City_____ Zone____ State_____

☐ Have an RCA representative get in touch with me.

XUM



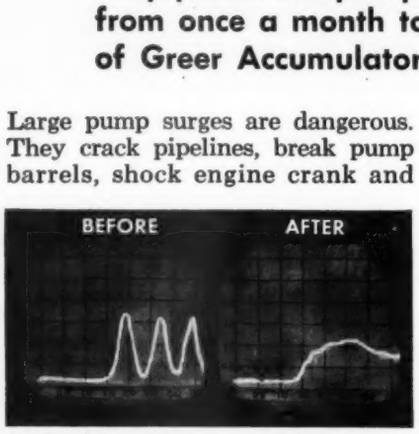
These three 5-gallon Greer Accumulators were installed on discharge side of Prescott double-acting duplex pump. Surge reduction was remarkable. See below.

CASE HISTORY OF PORTLAND PIPELINE PROVES:

Greer Accumulators Cut Pump Pulsations 53%

Oil pipeline and pump breakage were reduced from once a month to zero after installation of Greer Accumulators at pumping stations.

Large pump surges are dangerous. They crack pipelines, break pump barrels, shock engine crank and piston rods into failure. Greer has proved these failures unnecessary.

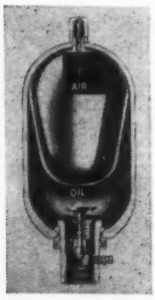


Hydrauliscope photos graphically prove pump pulsations were made harmless resulting in no further line breakage.

Comprehensive tests made at all eight pumping stations of the Portland, Maine to Montreal, Canada pipeline prove that Greer Accumulators will absorb pulses and render surges harmless.

Many pipeline systems—perhaps most—still suffer the costly consequences of these pressure surges. If yours is one of these, we urge you to investigate the simple and certain way to stop this waste.

Our experienced hydraulic engineers will demonstrate the Greer Accumulator to you without obligation. Please call or write.



How accumulator works: When system fluid is forced into accumulator under pressure, the gas in bag is compressed. Thus the rubber bag absorbs impact to an extraordinary degree. Write or call for Brochure 500 that gives detailed data on pump pulsation dampening.
U. S. Pats. under Olaer Lic.

GREER ACCUMULATORS

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Field Offices in Chicago, Dayton and Detroit · Sales representatives in all principal cities

The Author

H. S. Darby, superintendent, Motor Transport Department, Sinclair Pipe Line Company, was born at Conneautville, Pennsylvania, and his family later moved to Ohio, and in 1906 they moved to Independence, Kansas. His first employment was with Sinclair Pipe Line Company's predecessor, the Prairie Oil & Gas Company. Following assignments as office manager at construction locations, and as a field auditor, Darby served as chief clerk of the technical departments in Tulsa from 1924 to 1947.

In 1947, Darby was transferred to Independence as chief clerk of the Motor Transportation Department, a position he retained until his appointment as superintendent of that department in May 1953. He is a member of the Central Committee of Highway Transportation of the American Petroleum Institute, and of the Petroleum Motor Transport Association of Oklahoma.

area to which they are assigned.

Furthermore, even if the physical limitations of such equipment did not prevent its transfer to another area where equipment is needed to complete a specific job — and such limitations usually do preclude such transfers — the economics of transportation costs, and the very important fact that the equipment is needed in its regularly assigned area for maintenance work, eliminates practically all possibilities for such inter-area transfers.

Many Vehicle Types Needed

Applications of technological research in recent years have increased the number of vehicles required for pipe line operation and maintenance. Sinclair Pipe Line Company presently utilizes 26 classifications of vehicles. To mention a few motor body types, there is the telephone lineman light utility body, telephone line construction body, meter prover tank unit, electric and oxy-acetylene welding units, especially equipped units for corrosion engineers, electrical engineers, machinists, field gaugers, etc.

Included, of course, is the workhorse of the pipe line, the 2 to 3-ton gang truck with its power winch, gin poles, rolling tail pipe, headache post and other appurtenances, all of which facilitate work in the field. In the gang truck category, there is a definite distinction between the conventional oil field flat bed type, and the five man cab type with demountable bed and fifth wheel. This latter model is used by the products division, and permits the dispatching, in a single vehicle, of all the materials and equipment that will be necessary to complete the work at hand.

Mobile Communications

A most recent development, occurring in connection with the conversion of our communications system from

wires to wireless, is the installation of mobile two-way radios in many of our vehicles. In this connection, a procedure has been developed that will eliminate lapses in service when it is necessary to transfer the radio equipment from one vehicle to another.

For reasons of efficiency and economy, we strive toward standardization of our automotive and work equipment. To this end, we operate our own garage shop where most of our body repair, equipment fabrication and parts salvage work is accomplished.

The basis of our standardization program is the utilization of information provided us through field operations. It is, after all, through experience in the field that we learn of those things that will best serve our needs. This does not mean that we can standardize all equipment. We can achieve uniformity, however, in certain cases where cost, practicability, wide-spread usage, etc. lend themselves to such arrangements.

Improvements Sought

Quite often the adoption of new ideas for the improvement of our equipment results in important savings in time and money. For example, a different type boom, and a hydraulic steering device for our ditching machines, which reduces the handling of dirt and increases maneuverability, is now being used very successfully.

One of the continuing problems is to decide when it becomes more economical to replace an old unit of equipment rather than to continue making repairs. There is no fixed rule or formula to guide such decisions. Each case must be determined according to its particular circumstances. In our estimation, the paramount consideration is not the actual book cost of mechanical repairs, but the man-hours of labor that will be lost while older equipment is undergoing repair.

Continuing Research Is Aid

Motorized equipment presents an ever-changing picture, not only because of the day-by-day increase in mechanical refinements and improvements, but also because of the development of new fuels and lubricants.

In this latter connection, Sinclair Research Laboratories at Harvey, Illinois, work closely with the manufacturers of machinery, fuels, and lubricants, to assist them in the development and testing of new products.

The information gained from these research studies is most valuable to the motor transportation department, as are the opinions, analyses, and reports that they send regarding other specific questions and problems that we may present to them. * * *

Here's the biggest advance in Compressor Valves in 25 years!

...THOMPSON-ENGINEERED
to save you maintenance dollars

If you operate any type of air or gas compressors with valves from 2½" to 11½" in diameter, you can make important savings on valve replacement and compressor maintenance costs with this Thompson poppet type Valve!

See if this valve isn't everything *you* want for compressor service . . .

Simple Design – eliminates all complicated parts.

Rugged Construction – enables the valve to take the pounding of compressor service year in and year out without fail.

Increased Efficiency – gives better response to pressure and volume changes, with reduced wear on poppet valve, seat and springs.

Interchangeable – permits easy, economical changeover from your present valve equipment, regardless of type of compressor service.

Thoroughly Proven – Completely field tested over a period of several years. Thousands of these units are operating successfully in all types of installations.

Before you invest in any replacement valves, write Thompson for full details on Thompson poppet type Compressor Valves. There's a Thompson Field Engineer in your area who will gladly consult with you on your compressor requirements. Send for complete information – today!

Quick ENGINEERING FACTS ABOUT THOMPSON COMPRESSOR VALVES

Size range – 2½"-11½"

No. of poppets – 1 to 36

Type – Nylon for pressures to 1000 psi and temperatures to 280°F. Steel for higher pressures and temperatures

Pressure range – 0 to 5300 psi

Compression ratio – 1½-1 to 7-1

Temperature range – 80° to 450°

Stock–Cap, body, screw–SAE 4140 h.t. steel. Springs–oil tempered valve spring wire

Service–Air, ammonia, butane, propane, natural gas

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Westinghouse Microwave Letter

WESTINGHOUSE ELECTRIC CORPORATION, ELECTRONICS DIVISION, 2519 WILKENS AVE., BALTO. 3, MD.

Complete Microwave System Offers Coordinated End-Use Devices, Built-In System Protection

Westinghouse Type FR Microwave Radio assembly with Service Channel Panel and Alarm Panel (right). At left is the Remote Alarm Indicator.

Microwave is the latest medium for giving voice and control communications service. Westinghouse 2000 MC Microwave supplies this service in the best possible way—that of a complete system with full coordination of all elements. You get not only superior radio and multiplex equipment (combining high channel capacity with greater multiplexing reliability) but also excellent end-use devices and everything required (buildings, towers, surveys) for a complete, integrated installation. For even higher *system* dependability, special units are added to give overall system protection and added assurance of service continuity.

Service Channel Adds Efficiency

One of these special units is the Service Channel Panel, included with each Type FR Westinghouse Microwave Radio assembly. This channel provides party-line communications between all stations. It is not associated with the multiplexing operation of the 30 voice or 450 telegraph channels that can be provided by Westinghouse 2000 MC Microwave. In reality a 31st channel, the Service Channel is intended exclusively for installation and maintenance communication . . . designed to extend system efficiency and reduce operating costs.

Alarms Simplify Maintenance

Two more units of Westinghouse Microwave increase system performance by giving prompt notice of off-normal conditions. The Alarm Panel, associated with the Service Channel, reports up to six off-normal indications from up to 31 stations . . . on either the microwave system or on external conditions such as tower lights, low fuel supply or illegal entry. The second unit, the Remote Alarm Indicator, registers the nature of the condition and the station at which it is occurring.

Standby for Emergencies

Another system safeguard available with Westinghouse Microwave is Standby Radio equipment. A duplication of the operating radio equipment, this Standby simplifies automatic switching . . . can be arranged for instantaneous or delayed switchover. Standby also permits continuous system operation while preventive maintenance is performed on the operating equipment.

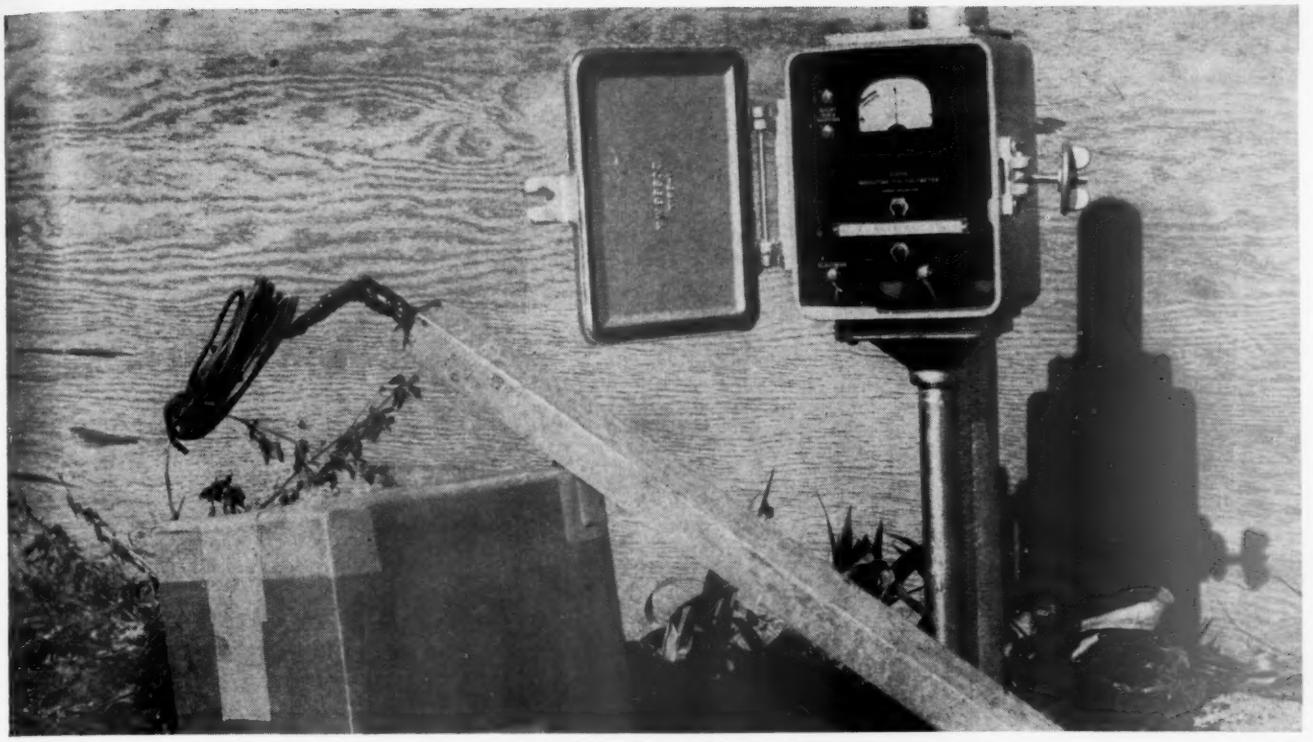
Superior End-Use Devices

All of these services of Westinghouse Microwave are derived from years of experience in microwave communications . . . from the knowledge that radio and multiplex alone are not sufficient for microwave service of highest reliability. Westinghouse realizes, too, the importance of end-use devices . . . is especially qualified, by virtue of a wealth of experience, in their manufacture and application. For full information about all of these matters, call your Westinghouse representative today, or write the Westinghouse Microwave Section at the above address.

Ask for our Microwave Booklet.

YOU CAN BE SURE... IF IT'S Westinghouse

J-02278



Complete meter kit, showing meter, zinc rod, and backfill.

Cathodic Protection Meters for Field Personnel

Checking installations made easier, less expensive through commercial development of permanently mounted meters for measuring pipe-to-soil voltages

JAMES R. COWLES

CATHODIC protection of pipe lines is well established, but the science is not so old that new developments have become rare. One notable development of the last year is the commercial appearance of indicating pipe-to-soil voltmeters intended to be permanently installed so that superintendents and foremen can be kept informed of the status of the protection at least on certain types of their lines without calling on an engineer.

In the past, such meters were not available except where some individual developed something special with the end result that many excellent cathodic protection installations have failed simply because no routine checking was possible except as a special project.

Certainly a remedy is over-due as the local supervisory personnel must look after cathodic protection just as they do other operations and such protection is often more subject to damage than other items. For example, a road grader can cut a wire much easier than it can a pipe.

Where to Use Meters

Protection by rectifiers and anodes falls roughly into two classes from a technical standpoint, the protection of bare pipes and the protection of coated pipes. On bare lines, including lines painted with primer or other such thin paint, these new meters are not generally applicable. They work best on coated or coated and wrapped lines, particularly when the lines are also carefully insulated, so that current requirements are small and any failure of insulating materials, failure to insulate new connections, or accidental contacts will divert almost all of this current to a pipe it cannot possibly protect.

Lines such as these generally have a decided change from end to end, in what is known as pipe to soil potential, or in less terse terms, pipe to copper sulfate electrode voltage. Naturally, the change is greatest near the rectifier or anodes, but in general, a change

The Author

James R. Cowles, consulting corrosion engineer of Tulsa, Oklahoma, was graduated from Oklahoma University in 1936 with a BS in engineering physics and from Massachusetts Institute of Technology with an MS degree in 1937. He was with the engineering department of Oklahoma Natural Gas Company from 1939 to 1954, inaugurating and heading cathodic protection work for ONG. He is now a consultant on cathodic protection and a manufacturer of cathodic protection instruments.

EXCLUSIVE

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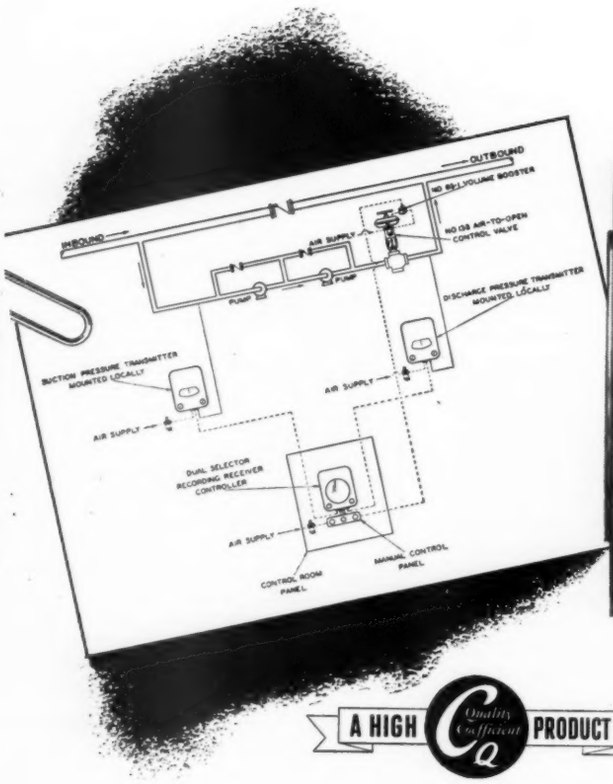

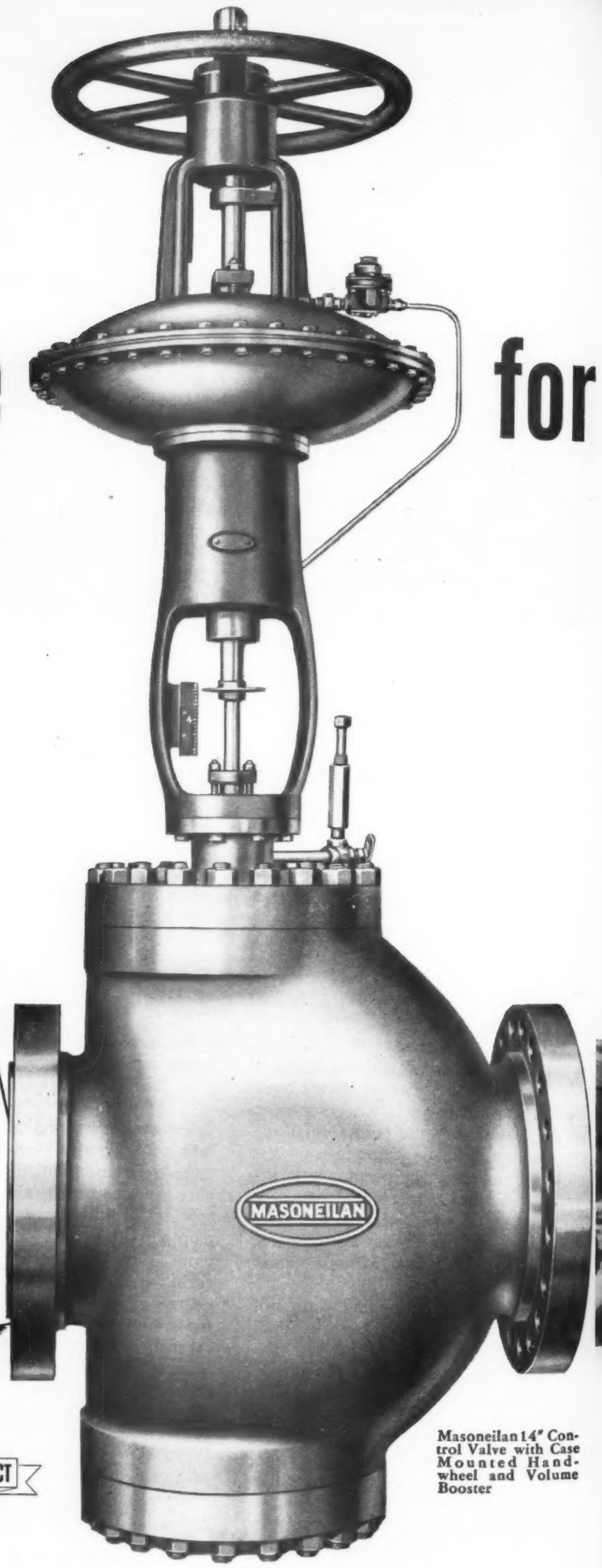

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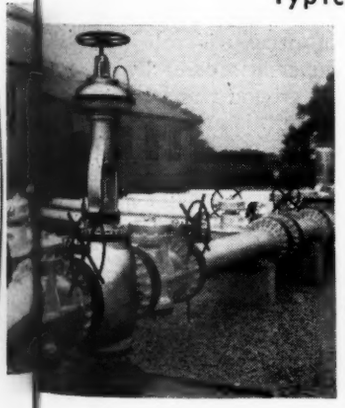
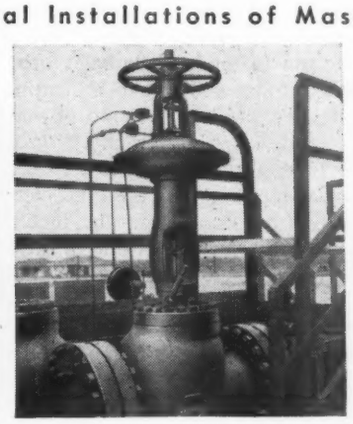
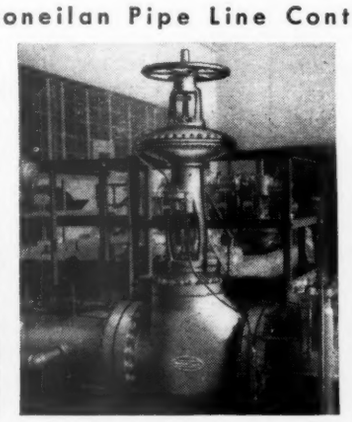
Pipe Line Control Valves

For years Masoneilan Control Valves have been the inevitable choice for large petroleum pipe line applications because Mason-Neilan has kept out front in development of pipe line valves. Only Mason-Neilan builds control valves, especially for pipe lines, including all these rugged structural features:

- extra large — 24 inch diameter — molded diaphragms with 330 sq. in. effective area.
- extra long stroke — up to 4 inches.
- 6-30 psi spring range plus large diaphragm area insures powerful motor.
- large diameter stems in keeping with generally rugged construction.
- steel diaphragm cases.
- spring barrel designed to permit use of cast steel yokes where required.
- extra long, heavy top and bottom plug guides.
- solid valve plugs of V-port design.
- oversize flanges available (e.g. 14″ body with 18″ flanges).
- sizes up to 16″ with body ratings to 1440 psi @ 100°F.
- high C_v with minimum pressure drop in open position, combined with desirable flow characteristics.

These superior features, combined with acknowledged Masoneilan quality, constitute still another example of why you get more for your money when you buy Masoneilan Control Valves.

Typical Installations of Masoneilan Pipe Line Control Valves

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HOT DOPE

Straight from the Kettle on *PIPE PROTECTION*

★

By Boyd Mayes

● Read not long ago that the cost of corrosion to industry each year is estimated at 6 million dollars. I don't have any idea how they arrive at it but in the pipe line business everybody knows it's pretty true. That's why when we started the business of coating and wrapping pipe we took a mighty careful look-into seeing that we got the very best in coatings and wrapping — and we got hold of the people with a reputation for doing work right and with products famous for dependability. We figure it's a lot better to have *friends who come back* for our services than *customers who don't*. Seems to us that a man's friends are his best advertisement — while just about anybody with *cash can be a customer* . . . and we just naturally like doing a job that gets praise. In our business we've seen lots of fly-by-nights in products and people and we find it satisfying to keep on using products and people that are tried and proved. Up in the Piney Woods somebody told old Jake that his hound dawg sure looked old — and Jake just said . . . "No — he's just SEASONED." That's what we think of our 26 years in the business too. We hope we have an opportunity to serve you this year. Men of experience and the best of equipment are at your service.

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from something in the neighborhood of 0.5 v to 0.85 v at the ends of the line is designed for. If any thing adverse to protection occurs the voltage on at least one end of the line will fall to near its original value around 0.5 v.

Two Types Available

A copper sulfate electrode and the necessary meter are not simple inexpensive items that any person can use. In addition to these disadvantages the copper sulfate electrode is not suitable for a permanent installation as it contains a liquid that must be replenished occasionally.

Through the years though it has been found that zinc, which has been extensively used as an anode, does have one of the properties of a copper sulfate electrode in that its voltage does not vary from time to time as does that of a steel, copper, or graphite rod.

In fact, it is so superior to other metals in this respect that its behavior in this manner is not one that would be expected and so it is not generally considered as good an electrode as it deserves to be.

It has one disadvantage. A meter connected between a zinc rod and a copper sulfate electrode will read close to 1.1 volts. This constitutes a correction to the voltage read between a pipe and a zinc rod if results are to be in terms of the reading between the standard pipe and a copper sulfate electrode reading. The handling of this correction has given rise to two types of meters.

One type meter[1] requires the voltage read on the permanently mounted meter be added to or subtracted from 1.1 depending on how the meter is connected, or in the case of a deviation of the zinc rod from the 1.1 voltage usually found, then the actual voltage read between the zinc rod (after it has been in place a month or more and therefore has reached a steady voltage) and a copper sulfate electrode.

The other type meter[2] eliminates this correction by a special meter arrangement for which a patent has been applied. The 1.1 v correction has been taken into account in the design of the scale and a meter chosen that will always be connected between the rod and the pipe in the same manner. Should the correction fail to be 1.1 v a limited adjustment can be made to completely compensate for the difference. If an unusual correction must be made, the meter can still be made to read correctly at the normal pipe-to-soil voltage of the line.

Indicating meters have several uses and advantages. First, of course, they check the primary object of burying anodes or installing rectifiers, a protective voltage. This is more of an advantage than it might seem, as is illustrated by the common policy of many firms to use the readings of the power company electric meter or those of the meters in the rectifier as a control to say that the line is protected from week to week or month to month.

Actually, this is a rather superficial control as in many cases the last four or five miles of the line could be removed from the ground and not change such readings as much as would moisture conditions of the ground from time to time.

There is no substitute for checking protective voltage at the weakest point. On routine installations, a notable advantage that can be taken of these meters is to obtain quick notice of trouble. Such notice can get personnel to the scene of the trouble while there are clues to the cause of the change, such as a freshly dug ditch for a side connection.

Trouble Shooting Made Easier

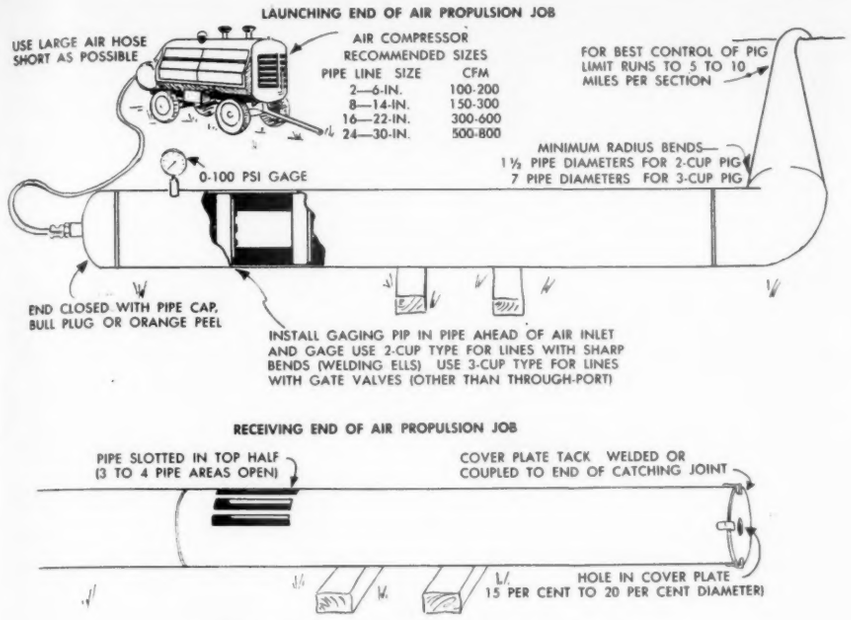
Such clues can save expensive troubleshooting as well as insure maintaining the 90 per cent "on time" some authorities set as necessary for effective protection. Another use of the indicating meter is to police a rectifier in inaccessible locations. This saves bothersome trips to the rectifier to be sure that it is operating.

Last, consideration should be given to policing the corrective measures taken to prevent the damage that rectifiers may do to power line grounds and anchors. Here, more than on a pipe line, adverse conditions not easily detected can occur. Damage to rectifier units and accessories can and does occur and those failures that subject the power line grounds and anchors to damage are not necessarily obvious. An indicating meter at a carefully selected power line ground will serve as a check on such unit damage.

In connection with the properties of the zinc electrode, attention is invited to the fact that such electrodes have value in their own right without an indicating meter attached. Permanent electrodes can be placed for spot checking with a portable indicating meter for some purposes. For example, a zinc rod buried under a large tank being constructed can be invaluable later. Many uses where an electrode in the same place from year to year has value will no doubt develop.

The ideas of the indicating pipe-to-soil voltmeter and the zinc electrode are not new, but the development of commercial meters is a milestone. Also, the writer feels that many uses for the zinc electrode will develop as they receive more notice. ★ ★ ★

[1]Dorr
[2]Agra


LAUNCHING END OF AIR PROPULSION JOB
USE LARGE AIR HOSE SHORT AS POSSIBLE
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24—30-IN. 500-800
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0-100 PSI GAGE
END CLOSED WITH PIPE CAP, BULL PLUG OR ORANGE PEEL
INSTALL GAGING PIP IN PIPE AHEAD OF AIR INLET AND GAGE USE 2-CUP TYPE FOR LINES WITH SHARP BENDS (WELDING ELLS) USE 3-CUP TYPE FOR LINES WITH GATE VALVES (OTHER THAN THROUGH-PORT)
RECEIVING END OF AIR PROPULSION JOB
PIPE SLOTTED IN TOP HALF (3 TO 4 PIPE AREAS OPEN)
COVER PLATE TACK WELDED OR COUPLED TO END OF CATCHING JOINT
HOLE IN COVER PLATE 15 PER CENT TO 20 PER CENT DIAMETER)

FIG. 1. Outline of operation of gaging pigs.

Cleaning lines can be hazardous; don't take chances, be sure to check the facts before

Using Air to Propel Pigs

B. VERNOOY

A TIMELY safety subject is the accident potential of air propulsion of pigs through hydrocarbon liquid and gas lines. There are many people who want to evacuate, separate, and clean oil, products, and gas lines with air. The fact that they usually express surprise at warnings not to use air as a propellant and the fact that many plants say they've done it for years, would indicate that they have been quite lucky.

There are several aspects to this problem. First, there is the operation of loading, unloading, transferring, and short haul fluid movement where it is thought best to eliminate contamination of one fluid by another by emptying the line between batches. Second, there is the construction process wherein the first fluid to fill a line comes into contact with air in the line and is required to displace this air. Third, there is the removal process where, in preparation for abandonment, the fluid in the line must be replaced by air.

In the first instance the problem is increasing. The use of loading and unloading facilities is rapidly growing with installations at many government air fields all over the world. Several organizations who previously had limited storage points are now building more storage and more complex piping arrangements to provide for greater volumes of fluid movement at more locations. The use of pigs in these operations has been adapted successfully from refined products separation to lube oil and LPG batching, the isolation of alcohols from gasolines, natural gasolines from crude oil and many "unpetroleum" jobs involving everything from liquid latex to chocolate. Much of this work is being done by military personnel, plumbing contractors, and others unfamiliar with the problems of petroleum pipe line construction or operation.

Use of the pig as a separator will be successful in each application only if certain basic rules are followed. First, the lines must be clean. A length of clean 6-in. pipe that will hold 8 gal of SAE 20 lube oil on its surface when drained down will hold 70 gal when it has a slight film of dirt on the surface. This cleaning can be accomplished by using caution during construction to keep out as much construction dirt, (earth and other debris) as possible. Before filling with its intended fluid the line should be gaged and pigged.

A gaging pig (Fig. 2) with a metal disc on the front slightly smaller than the pipe inside diameter can be air propelled through the line to remove any remaining trash, skids, rock, etc., and to insure that the pipe has a full round opening from end to end. A few runs with a brush type pig (Fig. 3) will then clean up the pipe to an operating cleanliness, removing not only dirt, but loose mill scale, weld slag and any water that may have accumulated in the low spots. (Fig. 4.) All this can be done by air propulsion with relatively low pressure and no hazard in new pipe.

Air, Products, Don't Mix

Air should not be used in pipe that has been in oil or gasoline service. Any

EXCLUSIVE

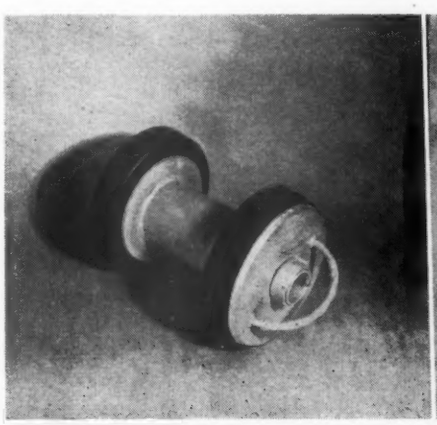

FIG. 2. Typical gaging pig for air propulsion through new lines.

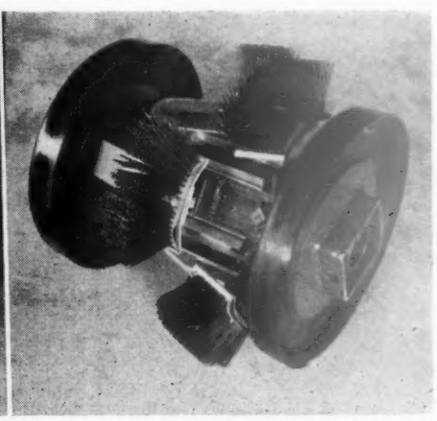

FIG. 3. Brush type cleaning pig designed for sharp bends.

XUM

dirt, internal scale, or rust will hold vapors for a long storage period and pipe that has been removed from one location and reinstalled at another has often been found to contain explosive mixtures when the residue is agitated as in pigging.

Note that the use of "explosion-proof" pigs is of little consequence. Such tools have been provided, but always with the caution that in no way can the user be assured that the rock, bolt, or welding rod picked up by the pig will also be "explosion-proof." Use of conductive rubber and spark proof bronze parts in pigs cannot be justified except for their limited value at the moments of installation and removal. The safest pig propellant in used pipe is water or, in cases where the contamination is no problem, the product to be moved through the lines.

FIG. 4. Blow of dirt preceding arrival of cleaning pig.

Procedures Determine Success

Once the line is in operation, the successful use of pigs for fluid separation becomes a problem of proper pig selection, adequate traps for installation and removal, and in some cases repeat-

The Author

B. VerNooy has been chief engineer of T. D. Williamson, Inc., for the last five years. Previous to this he worked with Ford, Bacon and Davis, Inc., and Plantation Pipe Line Company, first on original construction, later in operations and in design and installation of new facilities, and finally as engineer in charge of economic studies.

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ed cleaning or conditioning of the lines. Operating procedures can almost always be set up so that one fluid follows another with only the properly located pig between them. On the few occasions where one liquid must be entirely displaced before another arrives, natural gas or even propane at low pressure is the answer.

Under extreme conditions it may be that carbon dioxide gas or nitrogen is required and facilities can usually be arranged to recirculate the gas. Air should not be used under any circumstances and air propulsion of a pig to remove even the carbon dioxide or nitrogen should be avoided.

Line Filling Can Be Hazard

The second instance of hazard, that of initial line filling, is one which can easily be avoided by proper procedures. As in the case of terminal, dock and refinery transfer piping, the pipe should have the gaging pig run through it during construction to insure safe pig traversal during operation, to remove the larger foreign material and to locate flat spots and obstructions. Most pipe line contracts require that the contractor run this gaging pig thereby assuring that he'll be on the job to correct any faults it may show up. (Fig. 1.)

As a matter of safety, both the velocity and pressure of this air propelled gaging tool should be kept low. Its function is to locate the obstruction not to attempt to force its way past the flat spot or remove a dent. Whereas high pressures and velocities may damage both pipe line and pig, moderate speeds with a good slotted catcher on the end of the pipe will make for safe operation.

Where the initial fill of fluid is let into the line, it should be accompanied by a batching or all-cup pig. If there is any choice, it is best to use a fluid of lower volatility as the head of the stream.

If a highly volatile liquid or gas must be used, it should be allowed to by-pass the pig for some distance so that the pig is back from the head of the stream. This insures that any mixture immediately in front of the pig will be too rich to be ignited by the stone or bolt pushed through the line by the pig.

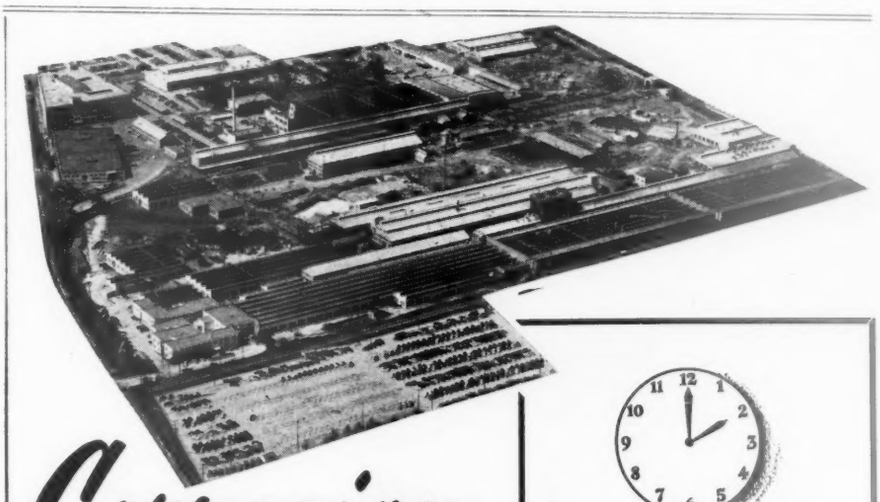
If no fluid is introduced in front of the pig the very small amount that may leak by can conceivably provide the correct mixture for ignition. Such leakage is probable in new lines where welding rods under the cup lip and dry, abrasive conditions can exist. A batching pig, which is back from the head of the stream, will do just as good a job of removing air from the high spots and water from the low spots to provide a complete line fill.

A desirable alternate to the above procedure is available where hydrostatic testing is employed. In such tests, one pig is used at the head of the water column to make a complete fill with no air pockets to provide a spongy test. Another pig is used behind the water and ahead of the line fluid to completely remove the water from the sags and valleys. There is little hazard involved with either pig in this event, but some conditions preclude the use of water.

Emptying Old Lines

The third hazard, that of emptying old lines preparatory to their removal from the ground or their transfer to a different use is the one in which we have the greatest accident history. A pig behind oil, gasoline, or natural gas and being propelled by a column of compressed air seems to provide all the requirements for an explosion within the line. In the cases experienced to date, the explosions were multiple, progressive, and in sequence. This would indicate that the first explosion caused a compression and resulting ignition of the air-fuel mixture at the point of second explosion and so on progressively down the line.

In each case the explosion started at



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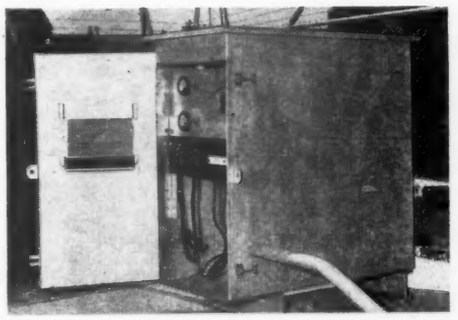

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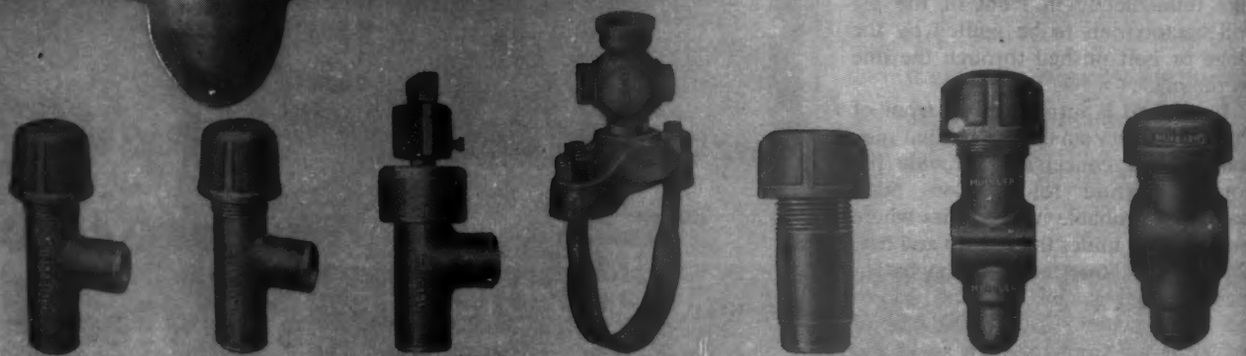

Service Tees ¾" through 2"

Service Valve Tees 1" and 1¼"

Curb Valve Tees 1" through 2"

Gas Main Stops ¾" through 2"

"Save-A-Valve" Drilling Nipples ¾" through 3"

Line Stopper Fittings ¾" through 2"

Extension Stopper Fittings 1½" and 2"

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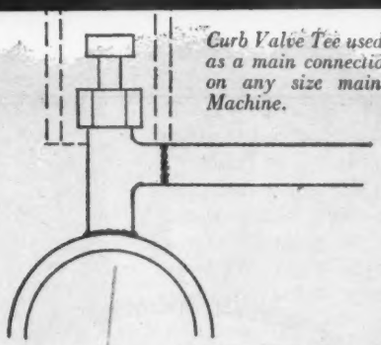

Curb Valve Tee used with Curb Box as a main connection and installed on any size main using "D-4" Machine.

Inserting valve mechanism into Valve Tee with a "D-4" Machine.

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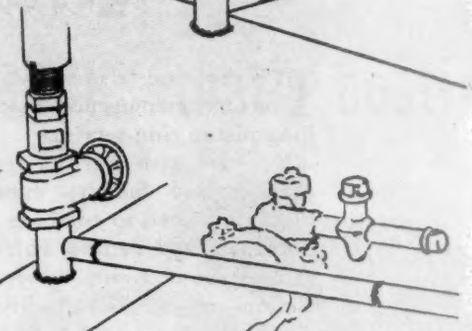
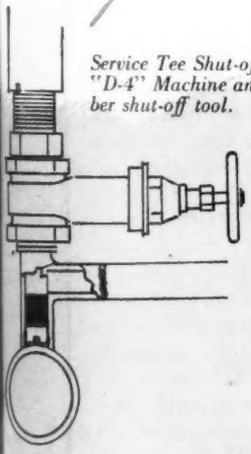
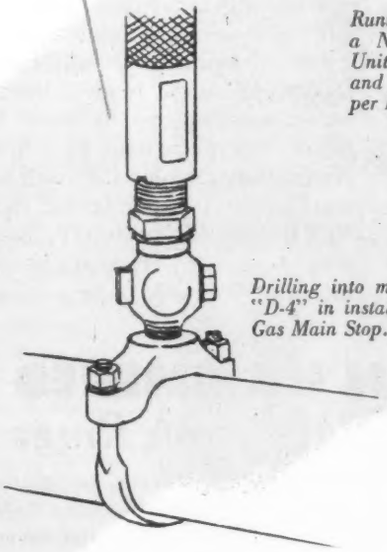


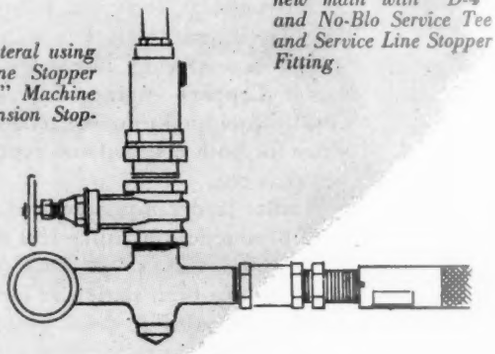
Setup used to transfer service from old main to new main with "D-4" and No-Blo Service Tee and Service Line Stopper Fitting.



Service Tee Shut-off with "D-4" Machine and rubber shut-off tool.



Drilling into main with "D-4" in installation of Gas Main Stop.



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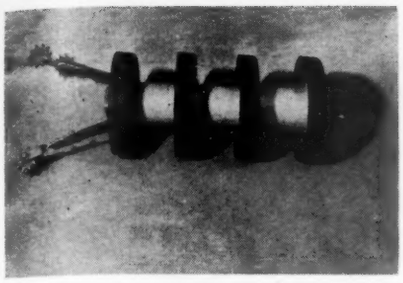

FIG. 5. Fluid separating or "batching" pig equipped with noisemaker to aid in location.

a point remote from the air compressor, which would indicate that the temperature or velocity of the air at that point was of no consequence. Pressure required to displace the line fill will seldom approach the ignition pressure of a diesel engine where ideal mixture control and vaporization are involved. If air leaked past the pig, it is conceivable that fluid surges could initiate an action similar to the Humphrey pump principle and that foreign objects moved by the pig could make a spark.

It is difficult, however, to conceive a mixture in front of the pig at all, let alone a mixture which was not too rich. This leaves few alternates as to the source of ignition.

One good possibility is spontaneous combustion of the residue in the pipe when exposed to air. It is not uncommon for the material removed by a cleaning pig to smoulder and smoke when removed from a sour gas or crude line. This is caused by the oxidation of sulfur compounds and since this oxidation is quite rapid, enough heat can be generated to set dry grass on fire. The oxidation of iron oxide removed from the interior of products lines is rapid enough to produce a visible change in color and it is possible that a newly agitated concentration inside the line could ignite an air-fuel mixture.

Propellants to Use

Regardless of the source of ignition, it is obvious that without air in the line there could be no combustion. Therefore, the only safe procedure is to eliminate the air as a propellant. There are only two alternates that are economically feasible in most cases. One is water and the other is natural gas. Water has the advantages of being less expensive, fireproof and usually more readily available. Its disadvantages are that it may introduce silt into the line, is difficult to dispose of (requiring drains at the low spots), and it hastens corrosion. Natural gas, when available under pressure is cleaner to handle and less trouble to dispose of. It is, however, hazardous and more caution must be exercised in transfer, propulsion and disposal. The use of nitrogen or carbon dioxide is not very practical for long line evacuation.

It must be noted that the use of natural gas or water will not clean the pipe. Subsequent operations such as pigging, cutting, welding, etc., must be carried on with the knowledge that an explosive mixture can still be present in the line.

Conclusions

The use of pigs to separate fluids (Fig. 5) in pipe lines for any purpose can be carried on safely and successfully as long as the adjacent fluids cannot make a combustible mixture. Pigs are used in oxygen lines, for instance, but extreme care must be taken to see that no oil or grease is present. Conversely, if oxygen or air is kept out of the system there is little hazard in using pigs in lube oil, crude oil, refined products, natural gas or any combination thereof. The use of water should be considered only as a safe, inexpensive, displacement liquid. Water has little value as a separating buffer between hydrocarbon fluids and the removal of the water from the fluids and the system is generally more trouble than the interface mixing would cause.

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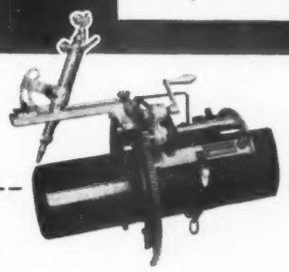

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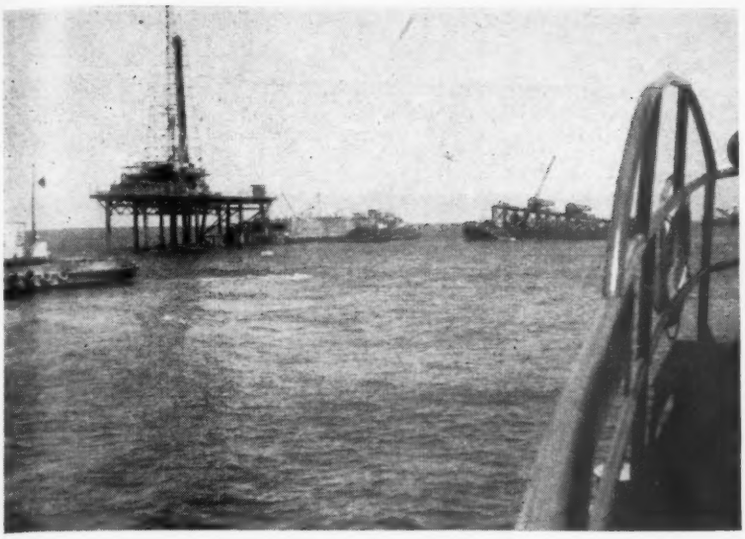

Phillips Petroleum Company-Kerr-McGee Rollover platform. Large barge to the right is the laying barge that laid new line.

Pure Oil Company Rollover platform. Crew quarters are on a separate platform directly behind the producing platform.

Weather, location, nature of installation makes some problems of marine lines harder, some easier than their land counterparts

Maintenance of Submarine Pipe Lines

ROBERT C. LEDFORD

THE problems of submarine pipe line maintenance, while of a similar nature to that of ordinary land pipe lines, vary to a sufficient degree to be of interest to all pipe line engineers and operators. Some problems involved are made more difficult by the nature of the installation. Some are made easier. All problems are compounded by lack of accessibility and vagaries of weather.

The Marine Gathering Company of Houston, Texas, for which the writer is manager of engineering and operations, constructed the first gas pipe line in the open waters of the Gulf of Mexico in July, 1950. This line was laid some nine miles out into the Gulf to pick up the gas and gas condensate production of the Pure Oil Company in the Rollover field. The field lies off Vermilion Parish, Louisiana, over 50 miles east of Cameron, Louisiana. This line was an 8⅝-in. pipe.

A second line was laid in July, 1953, again into the Rollover field but a mile farther into the Gulf to pick up the production of Phillips-Kerr-McGee. This line was 10 miles long and was constructed of 10¾-in. with 1⅜-in. concrete coating. The interim period between the construction of these two lines was of almost complete cessation of activities in the Gulf of Mexico occasioned by the dispute between the various states and the Federal Government over tidelands ownership.

Remote Location Is Problem

One of the great difficulties of maintenance encountered is the remote location of the lines and the necessity of having available for even routine maintenance jobs heavy and costly equipment capable of riding out heavy seas and stormy weather. Even though it is impossible during such stormy periods to perform the work, the equipment must be there so that it can take full advantage of good weather when such periods occur.

The nearest ports where heavy marine equipment is available are Harvey, Louisiana, 150 miles to the east, and Galveston, Texas, which lies approximately the same distance to the west. Thus the remoteness of the line location often means that such equipment may have to travel three or four days to arrive at the location from the nearest stationing point.

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This involves the additional expense of travel time on men and equipment in addition to stand-by time for bad weather and actual working time for completing any required repairs. For those who have had experience in marine work, whether in exploration, drilling, production or transportation, it is easily understandable that 90 per cent of the cost of a job can sometimes be charged to travel and stand-by expense, and only 10 per cent actually represent gainful occupation.

Such equipment is not required frequently enough to justify the company's owning it, and yet it must be available when needed. The necessary units to effect needed repairs may rent for $1000 to $3500 per day. It is possible for a repair job costing $500 on a land pipe line to cost $25,000 on a submarine line.

Use of Markers

On the conventional land pipe lines, at road intersections, river and canal crossings, and at railroads, it is customary for the pipe line company to place markers showing exactly where their line is situated. This is done not only for the convenience of their main-

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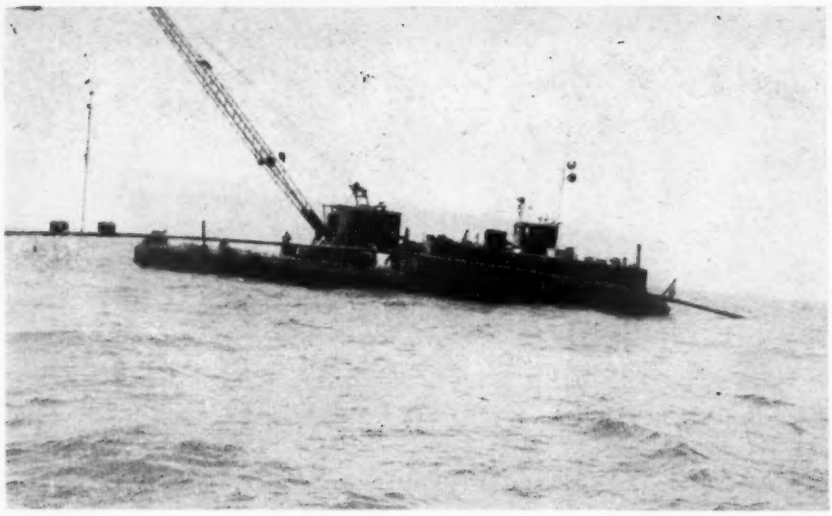

Typical line repair and maintenance barge. This barge would be augmented by two tugs and a crew boat.

Typical submarine line marker. Cathodic protection cables are in conduit welded to vertical pipe. Top structure is lighted at night.

tenance forces, but to warn others of the presence of the line in order to avoid accidental disruption of the service by cutting or bending of the line with grading or ditching equipment, dredges, etc.

In submarine pipe line design, markers are also used for the purpose of locating the lines and for warning marine traffic of the lines' presence. As such markers must be of heavy construction to resist sea action, they constitute navigational hazards and therefore in accordance with the requirements of the United States Coast Guard must be suitably lighted at night. Because electric power is not available, such lighting requires batteries, which means frequent servicing and inspection.

In addition, the markers themselves must be painted annually to protect the metal from severe corrosion. Special types of paints are being used and tested in order to determine those most economical and effective.

Swing Joints

Due to the fact that heavy wave action causes swaying of the producing platform, it was considered necessary to provide flexibility in the pipe lines at the point of connection to the platforms. Marine swing joints suitable for submerged service at 2500 psi working pressure were installed in the vertical risers to the platform.

As these joints provide 360 deg of rotation and so move with the sea action, it is necessary to provide lubricant to these joints by means of high pressure lubrication hoses that allows servicing from the platform above at all times.

Upon occasion, it has been necessary to replace joint packing due to pressure bubbles forming in the synthetic rubber retainer rings and causing leaking. This required the raising of the line and disassembling of these joints. A replacement of the type of synthetic being used it is felt will eliminate this difficulty in the future.

Cathodic Protection

A suitable installation of sacrificial magnesium anodes was attached to the pipe lines during the construction of the line. One anode bed was located at the beach where the submarine line comes ashore, and another was installed at the seaward line marker some six miles from the beach.

A very efficient application of corrosion coating and wrapping on the line was installed and it has been possible to keep almost 10 miles of pipe line under excellent protection with the two anode beds. The magnesium anode beds on the shore were spaced at 5-ft intervals along an axis perpendicular to the pipe line itself and buried to a depth of 5 ft to assure their being below the water table at all times. Because the soil is porous and comprised chiefly of shell, 50-lb bare anodes were used.

The anode bed on the offshore marker is comprised of two strings of 50-lb anodes, 5 per string, assembled and spaced on ¾-in. pipe, and connected by cable to the marker terminal and thence connected to the line.

Voltage potential has been in the magnitude of minus 1.20 to minus 1.28 v with a current drain of approximately 3.00 to 3.25 amp. Projected life of the anode installation is approximately 10 years and replacement of the beds should be a comparatively simple matter, since extra electrical cables were installed during construction for this purpose.

The hazard of sea action in breaking cathodic protection cables has made it necessary to make a complete check of the system at three-month intervals. Until the present writing, no such breaks have been experienced, but it is altogether probable that such breaks may occur in the future.

Line, Platforms Isolated

In light of the fact that the producing platforms themselves are under separate cathodic protection, it is necessary that the two systems be isolated electrically from one another, since the voltage potential and projected life of the two systems are designed with wide variance.

This isolation was obtained by the installation of micarta insulating sheets in the bolted supports that hold the pipe line to the platform, and by mi-

The Author

R. C. Ledford, manager for The Marine Gathering Company, has had a varied career in the petroleum, petrochemical, and pipe line industry. He began his career in the engineering department of Phillips Petroleum after attending the Missouri School of Mines. In addition to being a design engineer on portions of Dow Chemical Company's magnesium plant, he was construction superintendent on one of the first 100-octane gasoline plants completed in Texas during World War II, and chief engineer for the Barber Asphalt Corporation.

Recently, in conjunction with his activities with the Marine Gathering Company, he has acted as a consultant on problems of design for several pipe line and construction companies concerning submarine pipe line installations.

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The Problem

Cleaning waste liquids and solids from gas for pressurized reinjection into wells.

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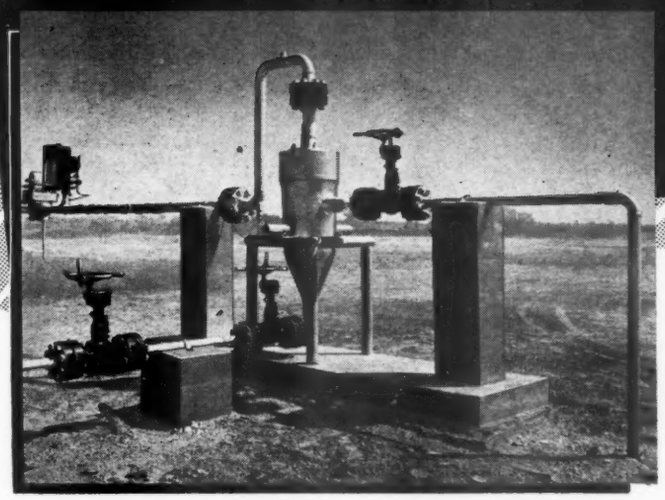
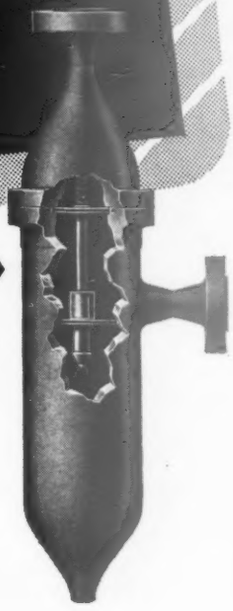
The Results

1600 gallons of waste products extracted daily from 9 million cubic feet of reinjection gas.



Installations of Aerotec Gas Scrubber at University, Block 31, Field, Crane County, Texas.



Cutaway section of Aerotec Gas Scrubber designed for high pressure applications.

New Proof of the practical, profitable advantages of Aerotec Dry Gas Scrubbers comes from the oil-producing industry. This backs up the long experience of natural gas companies with hundreds of units in daily use. These Aerotec Scrubbers, at wells and in pipelines, are cleaning foreign liquids and solids from natural gas with exceptionally high efficiency.

This Aerotec high pressure application is successfully employed by the Atlantic Refining Company in a jointly-owned claim in the University, Block 31, Field located in Crane County, Texas. The Aerotec Gas Scrubber removes components of lubricating oil from gas going to injection wells at 4,000 psi. It has also removed sand, mill scale and iron sulfides, and because no fluids are used in the separation process, no residue is carried over to the gas.

Additional units are now being installed before new injection wells are put into operation.

Lightweight and compact, Aerotec Gas Scrubbers are easy to install. Available in standard units up to 100,000,000 SCFD, they can be manifolded to meet larger requirements. For experienced engineering assistance in matching Aerotec Scrubbers to *your* specific need, or for catalog data on these units, call or write The Thermix Corporation.

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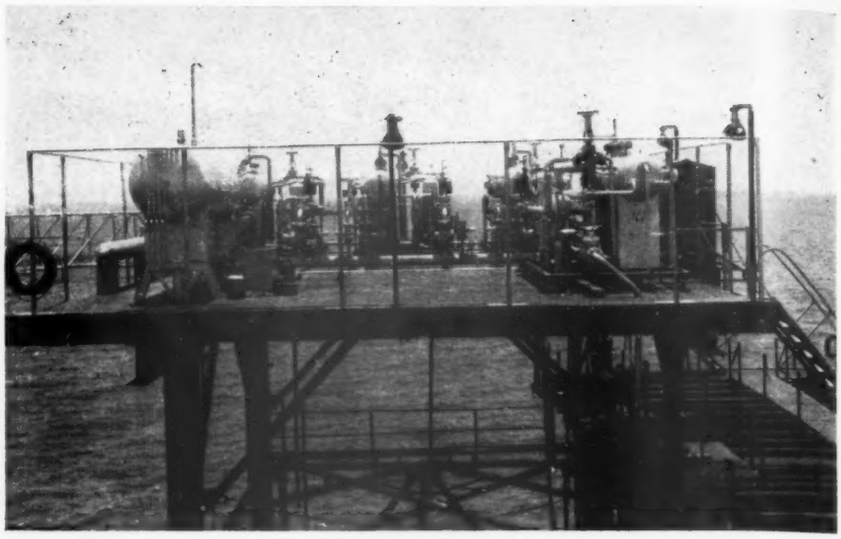
carta insulating ring joints and sleeves in the flanged connection that ties the production line into the submarine line. This makes it possible to hold a potential differential of up to —0.5 v on the two systems without leakage across the insulation.

Impressing a uniform current for cathodic protection is much more easily achieved on marine pipe lines and structures than on similar lines ashore, since the medium through which the current flows has constant resistivity. This is difficult to obtain in soil where alternate drying and wetting of the earth varies its ability to carry the return flow of current. At times some soils are able to insulate almost completely against the low voltage encountered in such systems.



Low temperature dehydration equipment on Pure Oil Company's platform.

Protection Effectiveness Observed

A number of opportunities to observe the effectiveness of the cathodic protection systems have been presented in the past four years of line operation. On the occasion of raising the vertical riser at one of the producing platforms for inspection of swing joints, it was discovered that floating debris had been pounded against the pipe during a storm with such force that over one linear foot of coating and wrapping materials had been completely stripped from the pipe line, leaving it bare to salt water attack.

The flow of current from the cathodic protection system had completely healed this breach by laying down a calcareous deposit approximately 1/32-in. thick and the pipe underneath this deposit was clean and smooth, without pitting.

To prevent reoccurrence of this type of damage, the design has been changed to incorporate a concrete coating 1½-in. thick from 10 ft below low water level to 10 ft above high water level.

Communications

Dehydration and metering facilities for these installations are some seven miles inland from the Gulf of Mexico because the land area bordering the Gulf is composed entirely of swamps and marshes. Communication between the operating force inland and the operating force on the producing platforms therefore, must of necessity be by radio.

It is essential that they be able to contact each other immediately at all hours, in case of any operating difficulty. In use are 150-watt transmitters of the frequency modulated type, installed at the shore station, on the producing platforms, and on all maintenance and operating ships used in the Gulf of Mexico. This type of communication lends itself well to the requirement encountered, reception and transmission being static-free and clear in all types of weather.

Maintenance on these units runs considerably higher than on most communication systems, due to the attack of moist salt atmosphere on soldered connections, tube prongs, condenser connections, etc. Water proofing sprays can minimize such corrosion.

In summary, it might be stated that because of careful consideration in original design and painstaking construction procedures, it has been possible to install submarine pipe lines that promise to have a long, useful life with a minimum of maintenance expense. Those items of maintenance that have been detailed above are those which seem to be unavoidable and a proper scheduling of that necessary work aids in keeping the cost to a minimum. * * *

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Continuous Weld—Threaded and Coupled	½" to 4" nominal I.D.	Uniform 21'	Standard	Fontana, Calif.
Continuous Weld—Plain End	2⅜" to 4½" O.D.	Up to 40'	Standard	Fontana, Calif.
Electric Resistance and Fusion Weld—Plain End	14" to 18" O.D.	Up to 40'	.250" to .500"	Napa, Calif.—Basalt-Kaiser
Electric Resistance Weld—Plain End	5⅝" to 12¾" O.D.	Up to 55'	.188" to .375"	Fontana, Calif.
Electric Fusion Weld—Expanded—Plain End	20" to 30" O.D.	Up to 40'	.250" to .500"	Napa, Calif.—Basalt-Kaiser

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XUM

P 615.511.3

Idle equipment is valuable — don't let condensation and corrosion damage it

Protect Your Electric Motor Investment!

FRANK C. OSTERLAND, JR.

THE trend in the petroleum industry toward substitution of electric motor drives for mechanical drives and toward the application of larger rated motors, many built for outdoor service, emphasizes the need for re-examining certain requirements necessary to keep them operating properly.

Today the pipe line field is employing a wide range of motors, from small general purpose types used by the hundreds in auxiliary applications to large high-speed pump and compressor drives in pipe line stations.

Danger to Idle Motors

In general, the necessity for in-service maintenance of motors — routine cleaning and inspection to assure consistent good performance — is well understood. But what about idle equipment? New motors that must go into storage until construction has progressed to the point where they can be installed? What can be done to protect units during prolonged shutdowns due to plant conversions or other factors?

The most common dangers to idle electrical machines are condensation of moisture on the insulation and mechanical damage resulting from rust and corrosion. For both new motors and machines that are being temporarily removed from service, the best protection is storage in a clean, dry area where above freezing uniform temperature can be maintained. Common sense will dictate the more obvious precautions against dust, dirt, physical damage, and against storing motors where overhead pipes can drip moisture on them.

Where ideal storage conditions do not prevail, a tarpaulin or some other covering can be substituted. Care should be taken, however, not to make a "sweatbox" out of the enclosure. Some moisture is always present in the atmosphere and surface condensation will result during temperature cycling. Adequate ventilation must be provided unless the motor is in a completely sealed package with suitable desiccant enclosed.

Again, moisture may condense on the insulation of a motor taken from storage when machine parts are colder than room temperature. This can be kept at a minimum by allowing the parts to warm up gradually.

Moisture Is Biggest Headache

These conditions for the proper protection of idle motors apply to all types, even outdoor service machines. Experience has proved that the latter will operate efficiently in all weather conditions. No matter how total the frame enclosure, however, no motor should ever be stored out of doors or allowed to stand idle for prolonged periods of time in uneven temperature storage areas unless suitable precautions are taken against damage to electrical and mechanical parts. So-called "total" enclosures breathe in moisture-laden air during temperature changes, and motor parts must be protected against condensation.

Moisture poses the biggest problem in protecting electrical machines. Electrical insulation can absorb enough moisture to reduce resistance values below safe limits, particularly in idle equipment. In tropical and semi-tropical climates moisture will speed the growth of bacteria, fungus, and other minute organisms that attack and break down organic insulating materials.

Condensation of moisture in motors which are not in use can be prevented by using heaters to keep the machine parts at slightly above room temperature. Enough heat to keep winding temperature about 5 C above the ambient is usually sufficient. However, in areas where wide and rapid temperature changes are experienced, a higher winding temperature may be necessary.

Space Heaters Useful

Where the machine is closed except for a small vent at the top and bottom for recirculation of air, the amount of heat necessary to raise the winding temperature about 5 C above ambient temperature is expressed in AIEE Standard No. 43, "Recommended Practice for Testing Insulation Resistance of Rotating Machinery," by this formula:

$$H = \frac{DL}{35}$$

Where

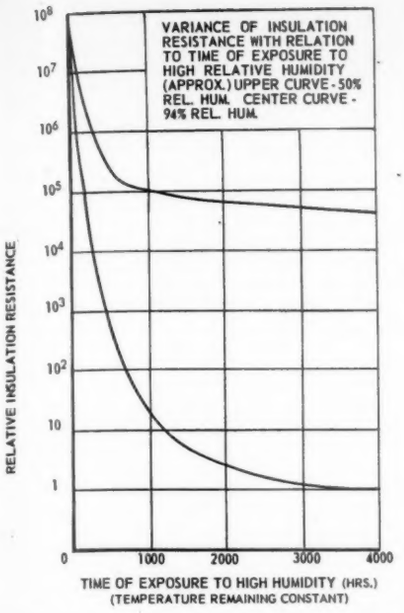
H = heat in kw
D = machine end-bell diameter in feet.
L = machine stator length between end-bell centers in feet.

This formula gives the minimum mount of heating required under ideal conditions. If space heaters are to be effective, the minimum temperature at any place within the machine enclosure must be maintained above that of the surrounding air. Stack effects in vertical machines and in others with special top or duct ventilated designs will cause considerable air movement and wide temperature variations inside the machine. And in out-door-weather-protected motors stored out of doors, winds will cause either suction or pressure venting and consequent air movement within the enclosure. Such cases

The Author

Frank C. Osterland, Jr., has been associated with the motor and generator section of Allis-Chalmers Manufacturing Company for over five years. He is a graduate of North Central College, and was an instructor in Junior High School, Racine, Wisconsin, for two years before joining Allis-Chalmers in 1948. Osterland is a lieutenant commander in the U. S. Naval Reserve and saw action in several Pacific Campaigns during World War II. He has written a number of articles on motor maintenance.

EXCLUSIVE



Curves show how insulation resistance decreases with increased exposure to high humidity conditions under constant temperature. Time is in hours.

may require as much as 50 per cent more heater capacity than is indicated by the formula.

Heat may be applied by any convenient and safe method. Electric space heaters, however, are usually the most suitable. They are available in various sizes and can be placed in service quickly and at low cost. Where unavailable, steam heating may be substituted.

Where motors are equipped with space heaters, they can be energized during idle periods to protect against excessive humidity. This is sometimes accomplished by relaying, in which case the heaters go into service as soon as the machine itself is de-energized. Where motors are supplied without space heaters, portable units should be installed within the enclosure.

Any effort to prevent the condensation of moisture on the machine insulation is generally worth while. Suitable precautions in this respect will decrease possibility of an insulation failure and may eliminate or shorten the special drying out process that is sometimes necessary.

Don't Forget Insulation

Insulation resistance tests are strongly recommended for all machines being installed. Where machines are being shut down such tests should be made and recorded before the motor winding temperature drops to room temperature. Periodic checks of resistance during shut-down periods can be compared to the readings immediately following shutdown to determine the extent of resistance drop through moisture absorption.

AIEE Standard No. 43 gives a concise summary of test methods, influencing factors and formulas for calculating approximate standard insulation resistances of various types of rotating machines. Significantly, moisture is not the sole factor affecting insulation resistance. Changes in temperature, cleanliness, age of windings, length of time of application of test voltages, all must be given consideration.

Equipment Must Be Dry

A variety of factors are involved in the need for drying electrical rotating equipment before placing it in service. These require experience and judgment to properly evaluate, and any question should be referred to the motor manufacturer for his recommendation. Generally, small low voltage equipment is placed in service without drying out, if it has not been unduly exposed to excessive humidity and moisture. A check should be made, however, to insure that the insulation resistance and polarization index of the windings are equal to or above the "standard value" of insulation resistances as recommended in AIEE Standard No. 43.

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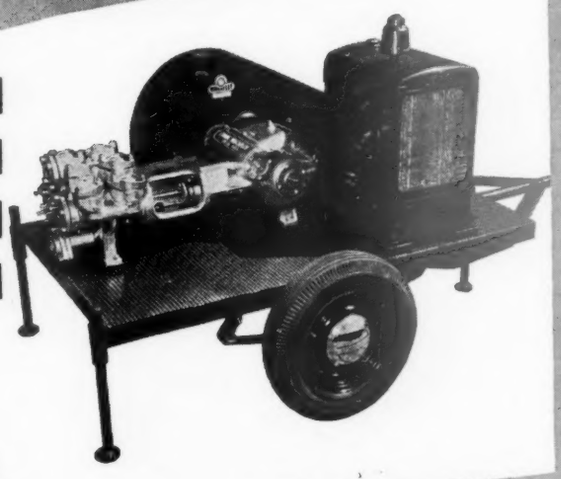

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2"	5	35	900	15	700
2½"	5	56	520	15	700
3"	5	83	350	15	700
3½"	5	115	255	15	700

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preceding criteria, are usually dried out before being placed in operation to take all possible precautions to assure service reliability and long life.

Bearings and journals of idle motors must also be protected against moisture damage. Adequate provisions are made by motor manufacturers for lubrication of these surfaces during operation, but the loss of protective oil films during shutdowns leaves them easy prey to rust and corrosion. This is especially true of sleeve-bearing motors. Anti-friction bearings should require no attention except to see that they are properly packed with the correct grade of lubricant.

Carelessness Can Be Costly

Field service engineers' reports emphasize that the seriousness of this threat is not fully realized. For example, a large totally-enclosed, explosion-proof motor that had been left outdoors several months awaiting installation was discovered to have no oil in the reservoirs, no protection from the elements, and was not equipped with space heaters. When its drain plugs were opened for inspection, water ran out of the oil reservoirs and rust was found on bearing parts.

Motor types used by the petroleum industry are usually completely assembled by the manufacturer before shipment. While practice will vary with suppliers, bearing parts are generally protected against rust formation during shipment and for a normal erection time. However, should weeks or months elapse between the time a motor is received and its initial operations, the advice of the motor manufacturer should be sought, and additional precautions taken.

Commercial rust preventives will protect clean metallic surfaces against moisture damage if properly applied. Some of these preparations have the advantage, when applied to sleeve bearing parts, of being soluble in lubricating oil, and requiring no special cleansing procedure before the machine is placed in operation. On horizontal sleeve-bearing machines, the compound may be added by pouring it through the oil ring inspection openings. At the same time, the shaft should be rotated to distribute the compound over the journal surfaces.

Another protective method is to fill the oil reservoir to the proper level with the specified lubricant, after making sure, of course, that all surfaces are free of rust and dirt. Then if the motor rotor is turned over every week, enough oil will be circulated to lubricate the bearing and journal.

To insure against damage to machines in long-time storage, or subject to extreme moisture conditions, periodic inspections must be made. If oxidation is discovered, all trace of it should be removed and additional rust preventive or lubricant applied to bearing parts.

Conclusion

Precautionary measures can assure that new motors, or motors removed from storage, are ready for service without undue delay for lengthy dry-outs or rust removal. A preventive maintenance program for idle as well as for operating machines will safeguard your electric motor investment.

* * *

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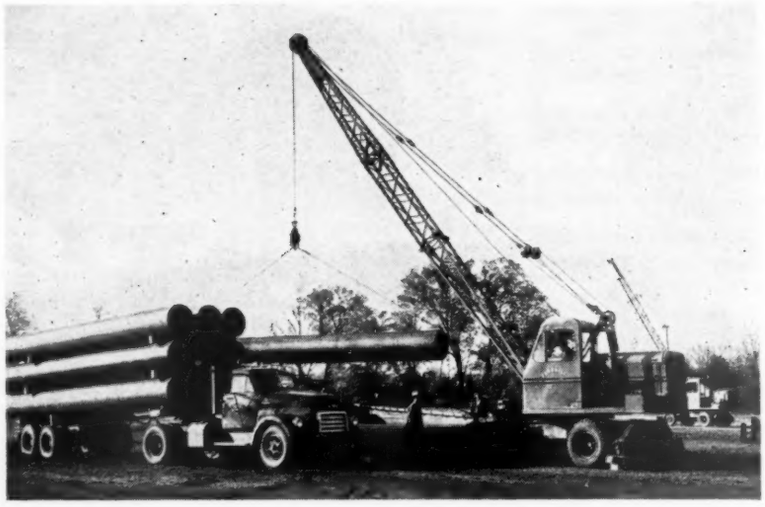

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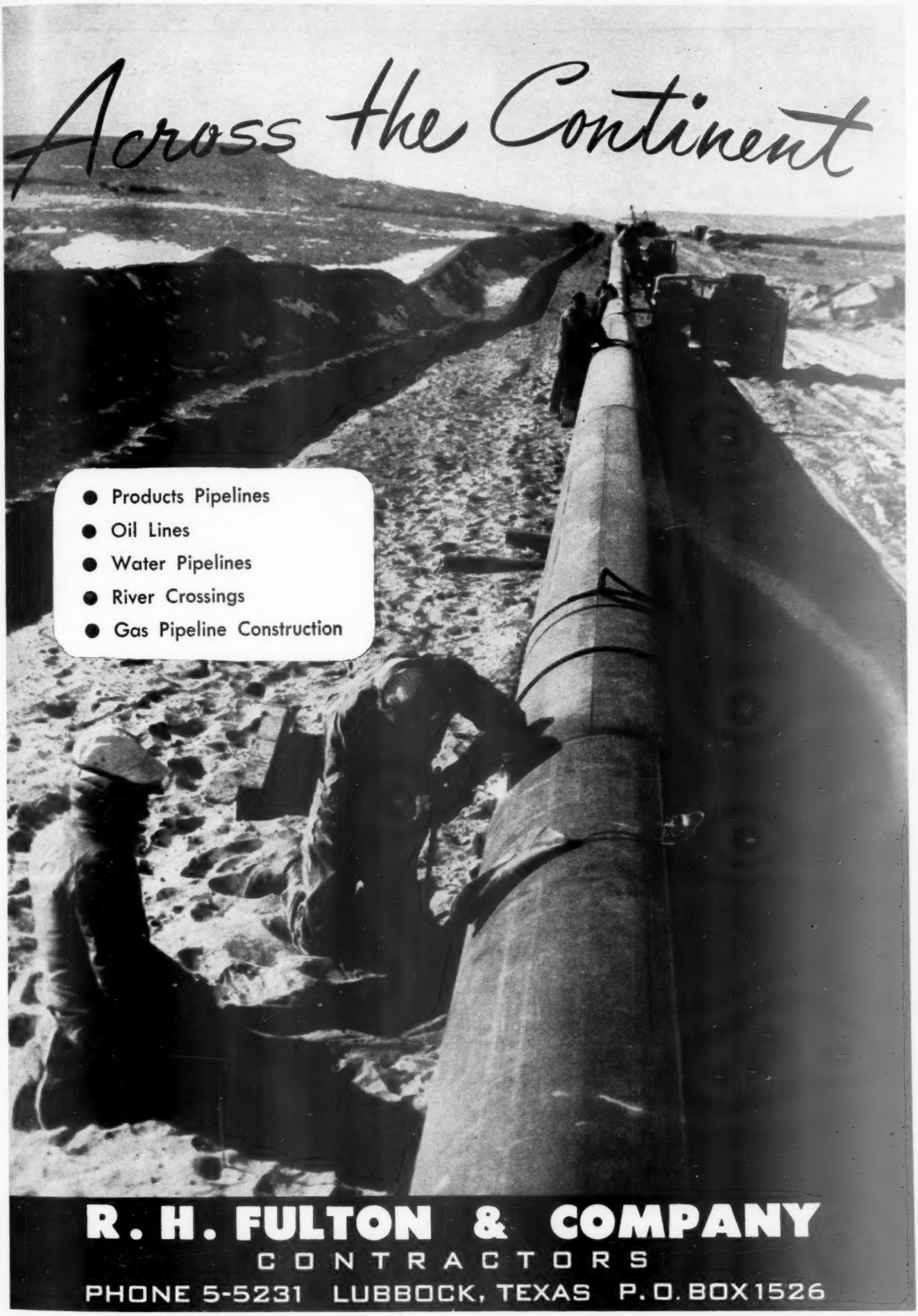
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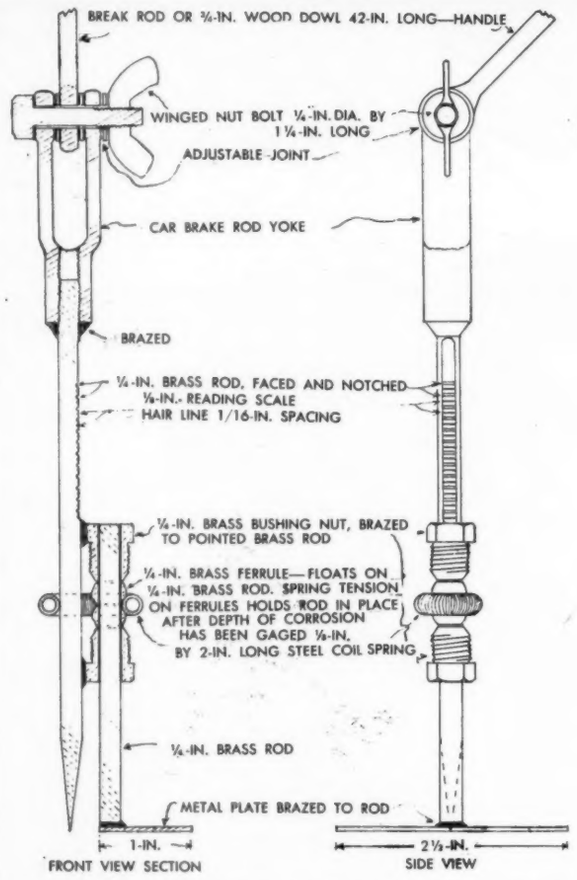
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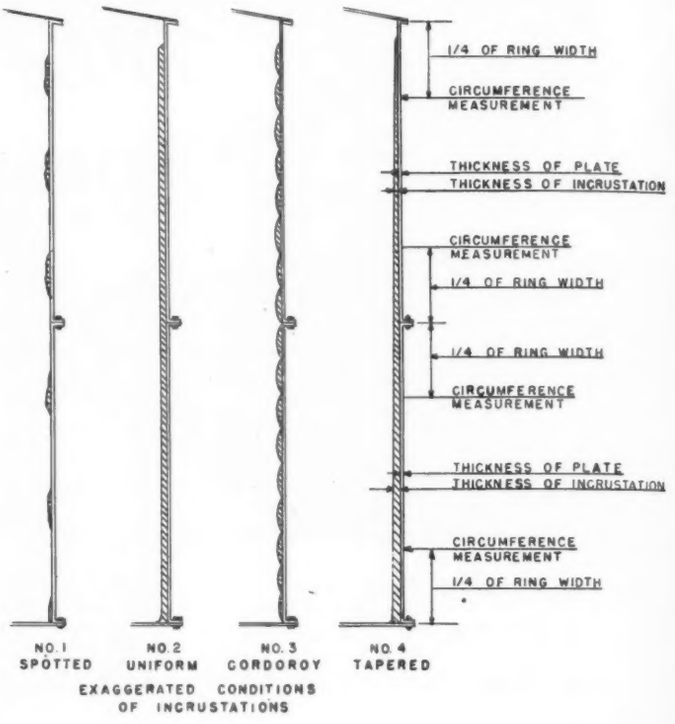
¼-IN. BRASS ROD
METAL PLATE BRAZED TO ROD
1-IN.
FRONT VIEW SECTION
2½-IN.
SIDE VIEW

Views of inscrustation gage designed for use inside lease tanks.This is depth gage type.



Shell incrustations cause decreased capacity in 500-bbl bolted tank. Four common types are shown.

Incrustation and Tank Capacity

Accumulations of tars, waxes, heavy oils, rust, water, light hydrocarbons, and soluble salts increases deadwood and lessens tank capacity; either cleaning or new tank table is answer

DEAN HALE*

INCRUSTATION and its effect on tank capacity is a problem of vital importance that affects the producer, carrier, refiner, and in some cases, the marketer. Incrustation occurs not only on the inside shell and supports of crude oil tanks, but also on petroleum products tanks. It is therefore essential that the inside shell and supports of all tanks be kept free as possible from incrustation in order not to affect materially the quality of crude oil or products run from the tank, averting any loss due to incrustation.

Basically, incrustation may be described as accumulation of rust, tars, waxes, heavy oils, free water, sulfur, and other substances that adhere to the inside shell and roof supports of a tank, displacing the contents. This has the effect of decreasing the original capacity of the tank.

Incrustation has prevailed on the inside shell of field tanks for years. In fact, it practically made its appearance with the advent of the steel tank. As fields increase with age, the tendency is for the build-up on the inside shell to increase more rapidly, in both sweet and sour crudes alike.

Types of incrustation vary from field to field, area to area. In some areas the buildup is soft and pliable, while in others it is of a hard, solid nature. Weather conditions and exposure of the tanks causes variable buildup. In some areas, paraffin sloughs off on the hot side, but sticks to the cold side of the tank, causing a normal buildup on the cold side, while only a thin layer is evident on the other. Rust accumulation and amorphous (dry) waxes cling the year around to the inside shell and supports in uniform layers.

EXCLUSIVE

Effect On Capacity

The tank strapper, in taking the measurements of a tank for calibration, determines the tank height, height of each ring, thickness of each ring,

*Editor, Oil and Gas Pipelining.

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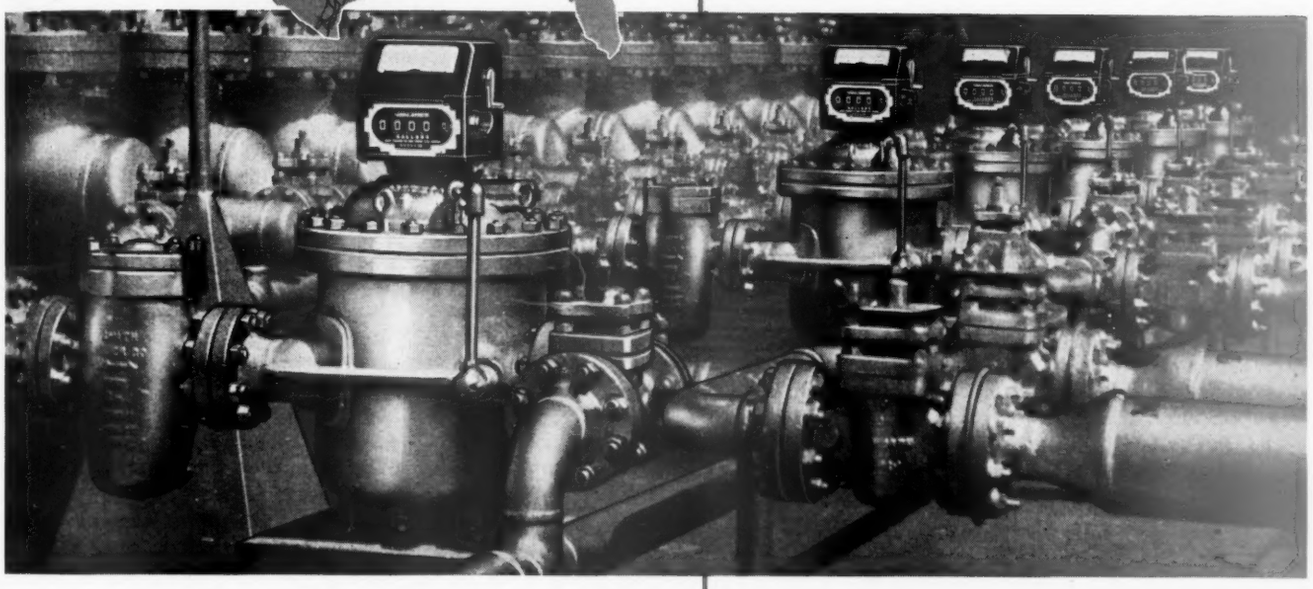

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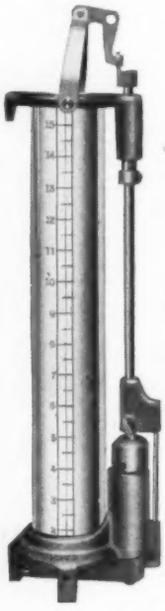

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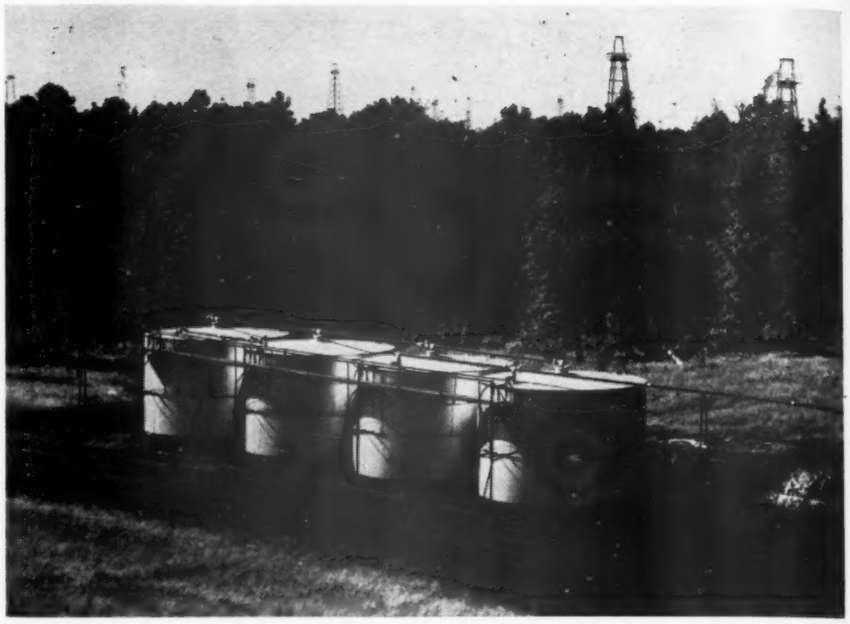

Typical tank battery installation, where problem of incrustation is probably most acute.

horizontal and vertical laps, circumference of each ring, type of shell construction, and the amount of deadwood within the tank.

Deadwood is described as any material within the shell of the tank displacing contents, such as uprights, cross pieces, braces, ladders, steam lines, pipes, flumes, etc. Accurate dimensions of all deadwood need to be taken, showing the location as to elevation from the tank bottom.

This information is provided the tank table engineer, who computes the tank table based upon the strapping report, determining inside shell capacity, less deadwood, reflecting the capacity in barrels and hundredth barrels for each foot, inch, and fractional inch in the vertical section of the tank.

Should additional deadwood be placed in a tank, or any deadwood removed, after the original table has been made, the list of deadwood should be corrected to conform therewith, and a new tank table prepared.

An accumulation on the inside shell and roof supports as shown would therefore be classed as deadwood, should be treated as such, and carefully measured. The owner may restore the original capacity of the tank by cleaning, or in some cases where cleaning is not considered practical, a new tank table may be prepared by the carrier according to the actual capacity of the tank reduced by virtue of incrustation. Devices of the depth gage or clipper type have been developed and are in use for accurate measurement of the incrustation.

Cleaning and Prevention

Cleaning operations on the inside shell of the field tanks will vary in different areas. Steaming the inside or

TABLE 1. Analysis of incrustations from interior for crude oil tanks. (All components reported as weight per cent.)

North Texas[1]

Sample number	Water and volatile hydrocarbons	Tars, Waxes, and heavy oils	Ferrous oxide (FeO)	Ferric oxide (Fe_2O_3)	Total iron oxide	Water soluble salts	Totals*
1	14.7	8.8	3.1	68.5	71.6	4.0	99.1
2	10.8	20.1	3.1	43.4	46.5	2.6	80.0
3	9.3	6.6	4.6	64.1	68.7	2.5	87.1

[1] The dried carbon tetrachloride extracts of the samples had the following appearances:
Sample 1: Soft, black wax-like material
Sample 2: Firm, black wax-like material
Sample 3: Black oil

East Texas[2]

Sample number	Water and volatile hydrocarbons	Tars, Waxes, and heavy oils	Ferrous oxide (FeO)	Ferric oxide (Fe_2O_3)	Total iron oxide	Water soluble salts	Totals
1	24.1	69.3	0.0	0.1	0.1	0.003	93.5
2	7.8	50.5	8.1	25.4	33.5	0.003	91.8
3	43.0	40.3	1.9	2.6	4.5	0.009	87.8
4	6.0	85.7	0.4	0.8	1.2	0.039	92.9
5	9.4	70.9	6.2	11.1	17.3	0.033	97.6

[2] No information available on appearance of samples.
* The difference between 100 per cent and the total amount of materials found includes such components as hydrocarbon-insoluble gums, water of hydration in the iron oixdes, and carbon and other inert material. The components reported as tars, waxes, and heavy oils are those materials which are soluble in carbon tetrachloride and are not volatile at 110 C (230 F).

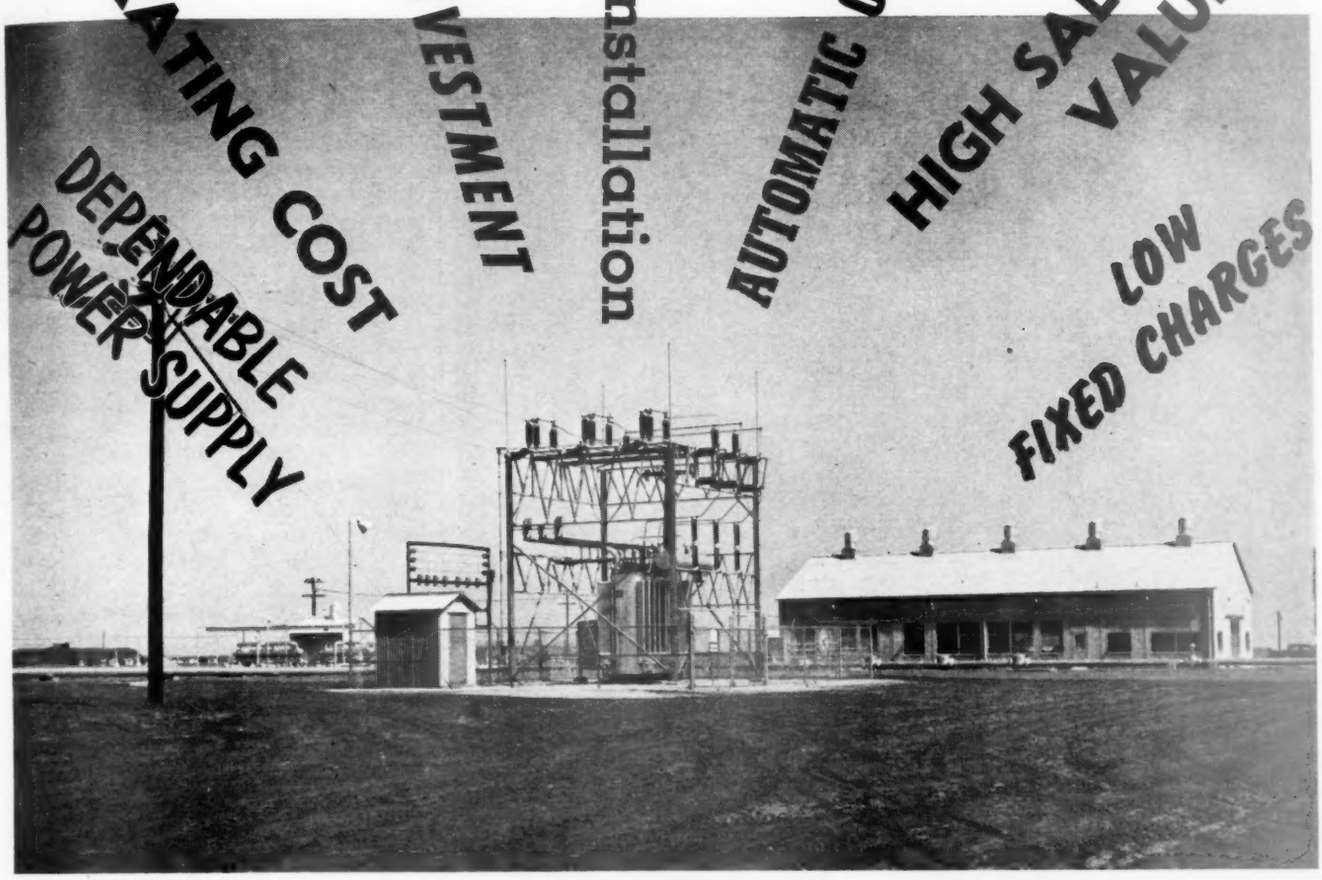

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TABLE 2. Calculated effect of adhesions on inside wall of lease tanks.

Tank Size Bbl	Height, ft	Adhesion scale and/or way inches	Bbl displacement
100	8	1/8	.43
		1/4	.86
		3/8	1.29
		1/2	1.72
200	10	1/8	.62
		1/4	1.25
		3/8	1.88
		1/2	2.26
200	15	1/8	.86
		1/4	1.72
		3/8	2.58
		1/2	3.44
210	15	1/8	.87
		1/4	1.74
		3/8	2.61
		1/2	3.48
250	8	1/8	.63
		1/4	1.26
		3/8	1.89
		1/2	2.52
300	15	1/8	.98
		1/4	1.96
		3/8	2.94
		1/2	3.92
400	20	1/8	1.33
		1/4	2.66
		3/8	3.99
		1/2	5.32
500	8	1/8	.88
		1/4	1.76
		3/8	2.64
		1/2	3.52
500	16	1/8	1.35
		1/4	2.70
		3/8	4.04
		1/2	5.39
1000	16	1/8	1.88
		1/4	3.76
		3/8	5.64
		1/2	7.53

applying steam on the outside will work satisfactorily in waxy areas. In other areas, where corrosion and rust prevail, sandblasting and scraping will be required.

Incrustation can be materially reduced, and in some cases eliminated, protecting the inside shell and roof supports, by galvanizing or by use of certain paints, coatings, or plastics.

Plastics have been used for several years in West Texas areas, giving some protection from corrosion and assisting in reducing shell accumulations.

Plastic coatings under development prove valuable in preventing corrosion and reducing the problem of incrustation.

Analysis of Samples

The analysis of samples in one field shows approximately 15 per cent free water and light hydrocarbons; nine per cent tars, waxes, and heavy oils; and 70 per cent ferric oxide or rust. In another area, the samples show 43 per cent free water and light hydrocarbons; 40 per cent tars, waxes, and heavy oils, and three per cent ferric oxide or rust.

The difference between the totals and 100 per cent includes such components as hydrocarbon insoluble gums, water of hydration in iron oxides, carbon, and other inert materials. Other areas show a combination of the above tests plus a corrosive action in sour crude areas. Analyses of incrustration typical in North Texas and East Texas fields are shown in Table 1.

The calculated effect of incrustation

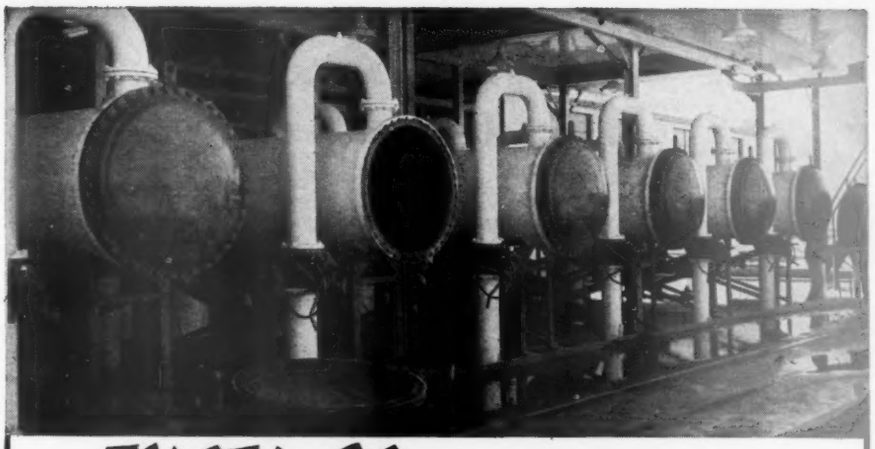
or adhesions on the inside shell of field tanks can be readily seen by showing as an example a 100-bbl bolted tank, 8-ft oil height, where ⅛-in. incrustration equals .43 bbl, ½-in. equals .86 bbl, ⅜-in. equals 1.29 bbl, and ½-in. equals 1.72 bbl.

For a 250-bbl bolted tank, 8-ft oil height, ⅛-in. incrustation would equal .63 bbl, ¼-in. equals 1.26 bbl, ⅜-in. equals 1.89 bbl, and ½-in. equals 2.52 bbl. In similar cases, a 500-bbl bolted tank shows 5.39 bbl displacement and a 1000-bbl bolted tank shows 7.53 bbl displacement with a ½-in. incrustation, oil heights on both tanks being the same, or 16-ft. Table 2 gives a complete tabulation for 10 different tank sizes.

Economically speaking, the losses due to incrustation, whether in the field or other operations, can be serious, and prevention or elimination of such losses is essential to all branches of the industry. Studies are being made and research underway, which will undoubtedly do much toward minimizing the problem in the future. * * *

West Texas Line

A new 26-inch pipe line in West Texas will move 440,000 barrels of oil per day; this much oil would require 18 trains of 100 tank cars each to do the same job.



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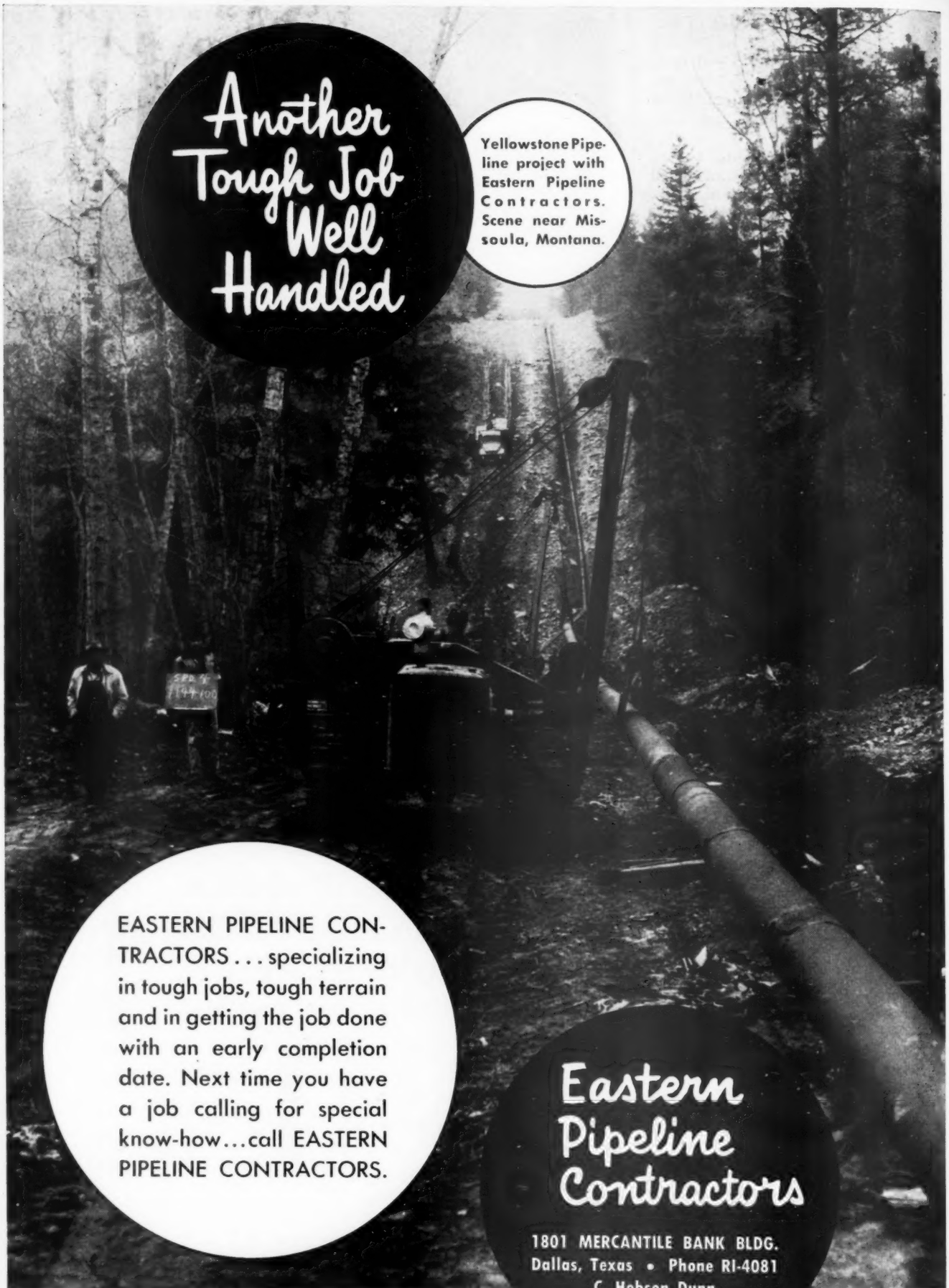

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Yellowstone Pipeline project with Eastern Pipeline Contractors. Scene near Missoula, Montana.

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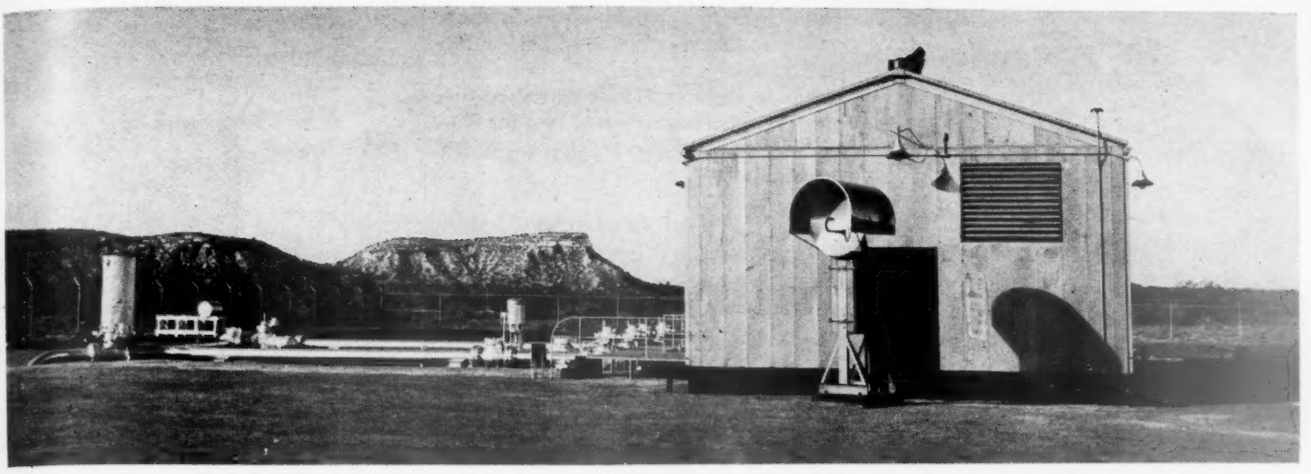


Sterling City pumping station is controlled and metered by microwave and is unattended. Signals received and transmitted by reflector in front of control station housing.

Even a damaging tornado didn't halt operations or impair dependable service on the system during

Pan American's Three Years With Microwave

CLYDE R. HEPLER

THE tornado that jarred San Angelo, Texas, during May 1953, also paid a call on the Carlsbad microwave station of the Pan American Pipe Line system. It wasn't a very friendly call. The tower top was left swaying erratically through a 6-ft arc. All the steel support cables were ripped three or four feet through the guy clamps. A whole section of the REA power line serving the area was torn out and a half mile length of it was found tightly wound around the twisted tower. The sun meter that controls the tower warning lights, mounted 30 ft up the mast, was thoroughly smashed and a large rock was found inside. The sheet metal building that housed most of the electronic equipment was tilted precariously. The outdoor housing for the microwave frequency circuits was dented and pitted, apparently by stones and pebbles flung against it by the high winds. Despite the damage, the microwave station never went completely out of operation.

Throughout the night, operators pushed their messages through as the tower top passed through the center of its arc. In the morning, a crew straightened the tower by tightening the guy cables one at a time until it was pulled back into shape. The half mile of power cable was unwound, the sun meter replaced and the building was tipped back in place and reshaped. The microwave system operated just as it had before the storm.

Although the microwave system is made up of a number of electronic circuits that require careful adjustment, its basic simplicity provides the ruggedness demonstrated at the Carlsbad station. The Pan American system is the spine of a communications network through which all the pipe line activities in West Texas are coordinated. Frequent or prolonged failure would be prohibitively costly.

Pan American's pipe line carries oil from gathering stations in fields at Snyder, Vincent, and Hulldale through west central Texas to Concho station outside El Dorado. At Concho, oil is stored for eventual delivery elsewhere through another pipe line, the Rancho system.

The trunk of the microwave system consists of seven stations that form a zig-zag line 142 miles long, roughly parallel to the pipe line between Snyder and Concho. Off this trunk, there are two branches that extend to the pumping stations at Sterling City and Arden Junction.

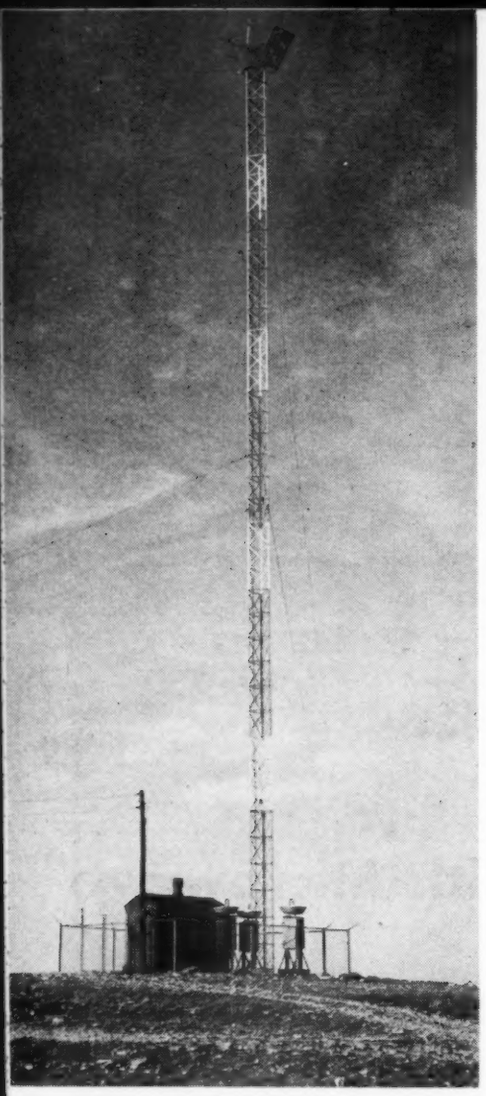
On the carrier, Pan American superimposes six separate voice signals in individual subcarrier channels. By adding a few small components, at the desired stations, the pipe line could increase the capacity to 12 voice channels. By using later versions of the same relatively inexpensive units, the capacity of the system could be increased to 24 voice channels if future conditions warranted the expansion.

Some of the stations merely receive the modulated carrier and retransmit it in a different direction. At others, certain of the voice channels are extracted

The Author

Clyde R. Hepler is superintendent of electrical and communication section, Pan American Pipe Line Company, Houston, Texas. He entered electrical and communication work in 1922 with the Houston Lighting and Power Company. After working with the power company and several oil pipe line companies for a number of years he was employed as a consulting engineer in 1940 by the Pan American Pipe Line Company for the original construction of the company's electrical and communication system and has been with them since, except for three years spent in the Navy during World War II as a communication specialist.

EXCLUSIVE



Pan American's Carlsbad station was hard hit by a tornado in 1953, but never went completely out of operation. This is same station several months later.

and are fed to a switchboard or a series of telephones or even to a VHF radio station for transmission to cars and trucks in the area. These extracted signals may also be reinserted into the carrier for further transmission on down the microwave system trunk.

Use of Channels

Two of the six subcarrier channels are private circuits, terminated at only two stations. One extends between Snyder and Colorado City and the other between Snyder and the Concho station. These two channels normally carry messages not directly pertaining to the operation of the pipe line.

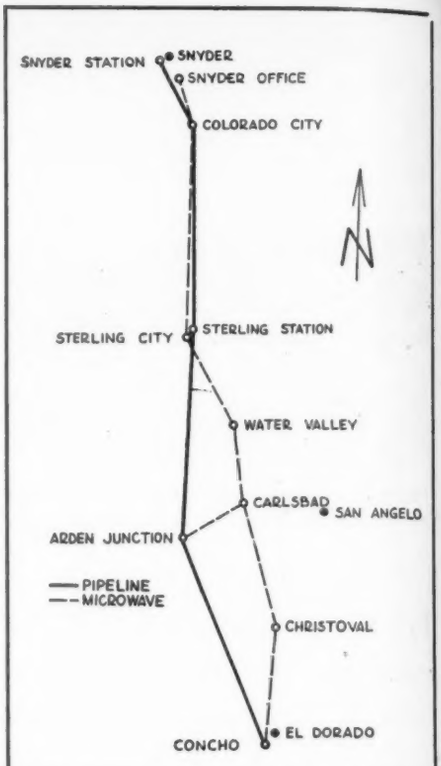
Two others are used to remotely control VHF base stations. Through one, operators at both Snyder and Colorado City control the VHF radio station at Carlsbad, and through the other, the operator at Snyder controls the VHF unit at Concho.

The fifth channel is a party line circuit, terminated at every attended station on the microwave system. This circuit is reserved for communications concerning pressure, temperature and oil movement.

The last channel is a supervisory control and telemetering circuit between the Sterling City stub station and Colorado City. This circuit permits an operator at Colorado City to control all operations and observe the variable conditions at the completely unattended Sterling City pumping station.

Design of Stations

All the microwave stations except the two stub stations look alike. Each



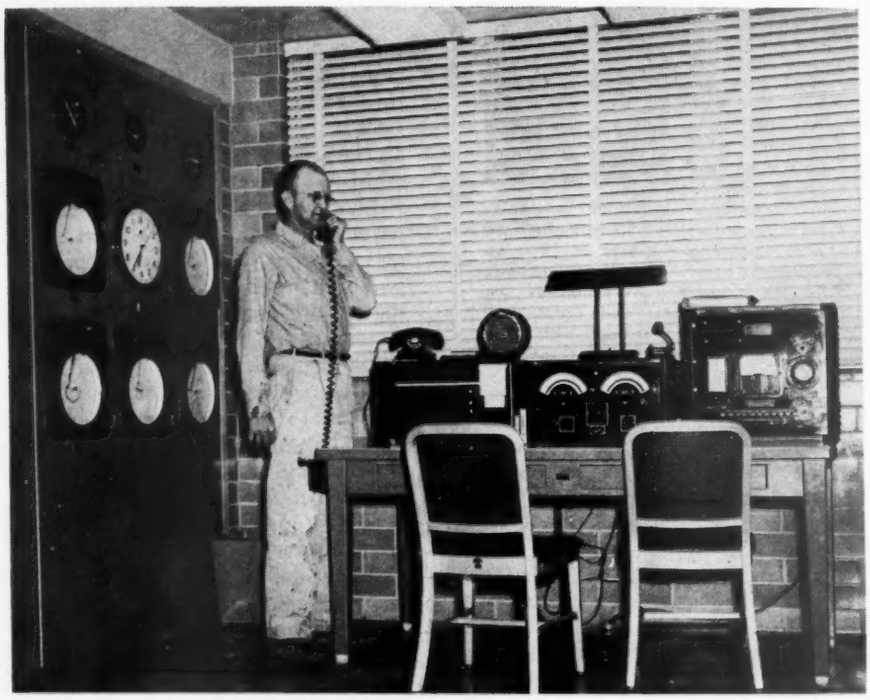
Map shows routes of pipe line and microwave system.

is located on the highest point in the vicinity so that the signal paths pass well above possible obstructions. Each tower is 140 ft high for the same reason. A small sheet metal building is located at the base of the tower to house the multiplex (subcarrier) equipment and the standby power generator. Heavy gage aluminum cabinets outside the building contain the microwave radio frequency circuits that are controlled through cables extending from within the building.

The microwave signal is sprayed from the end of the antenna horn onto the face of a parabolic reflector mounted on top of each aluminum cabinet. The signal is beamed from the parabolic reflector to a tower-top reflector so oriented that the signal is redirected horizontally toward the passive reflector on the next tower. Signals to be received flow in the reverse direction over the same path on a carrier of slightly different frequency.

Each station has a separate RF system for each signal path over which both incoming and outgoing messages travel. This method of signal direction is employed because it eliminates use of coaxial cables, a common source of trouble, yet does not necessitate the construction of towers capable of supporting heavy equipment.

At the two stub stations, the parabolic reflector beams the signal directly to the next tower from ground level,



Delivery man at Concho station calls Snyder office over the private microwave circuit.

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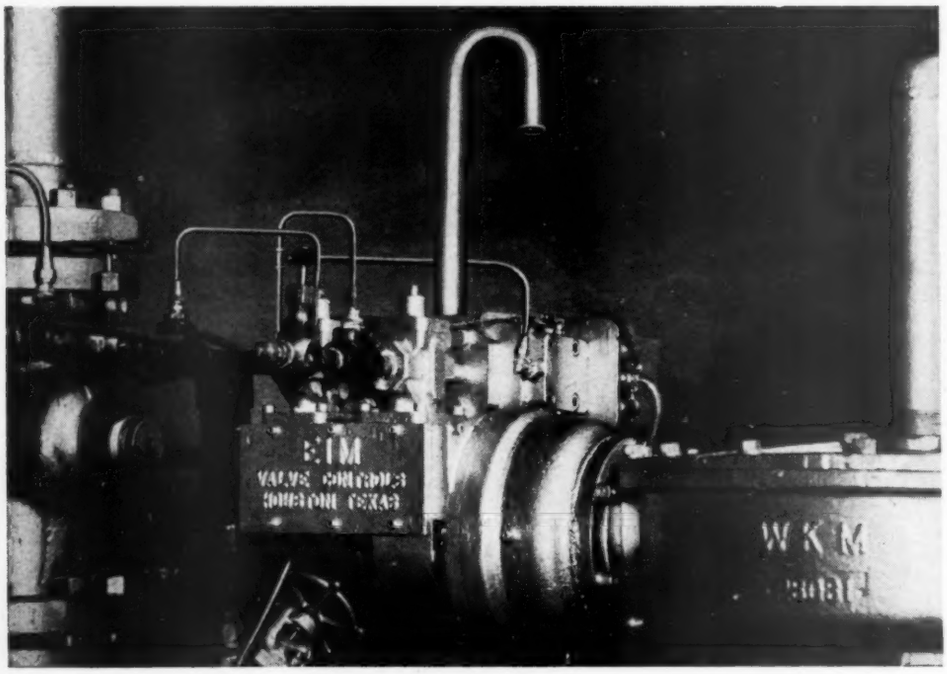

The G2 takes its source of power from the medium in the transmission line, without any pressure reduction. There are no small parts. It's a compact unit with all piping, valving and controls integrally arranged. Field piping is kept to a minimum. Actually, only one small line from the pressure source to the valve control is required.

Some 180 Type G-2 valve controls are employed in Texas Eastern Transmission Company's stations and along the line.

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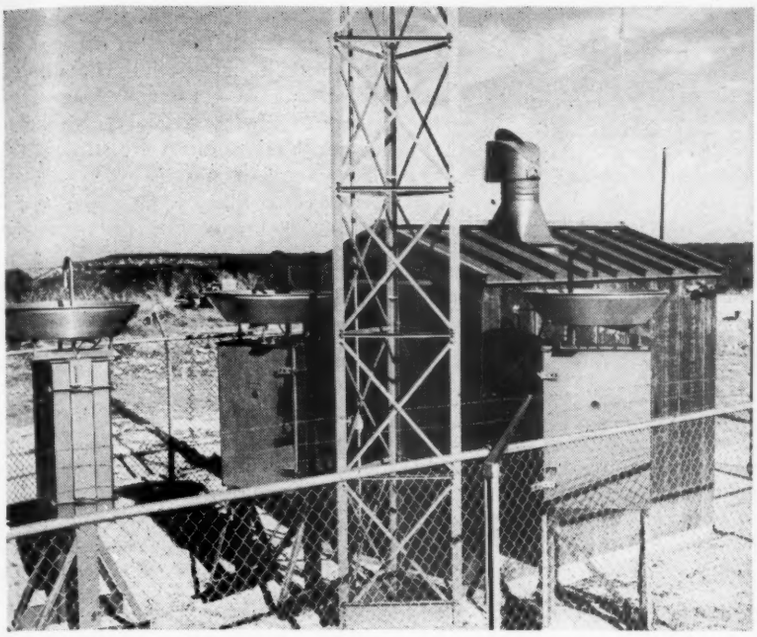
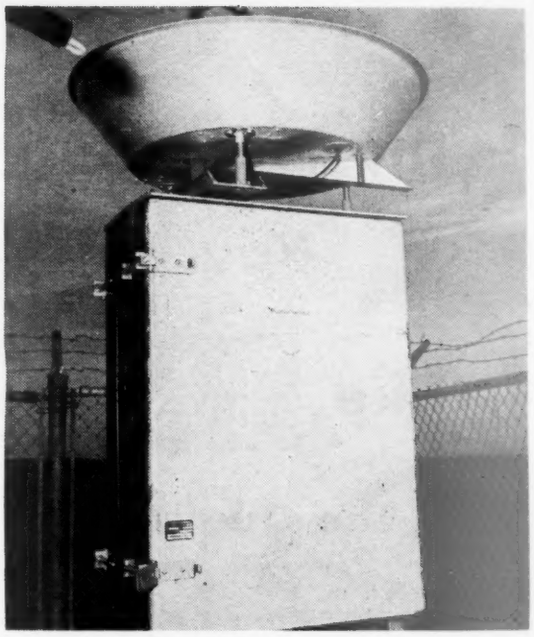


Parabolic reflectors beam their signals upward to three passive reflectors mounted on Sterling City tower.



RF housing at Carlsbad station, scarred and battered, is the only testimony to tornado that damaged equipment there.

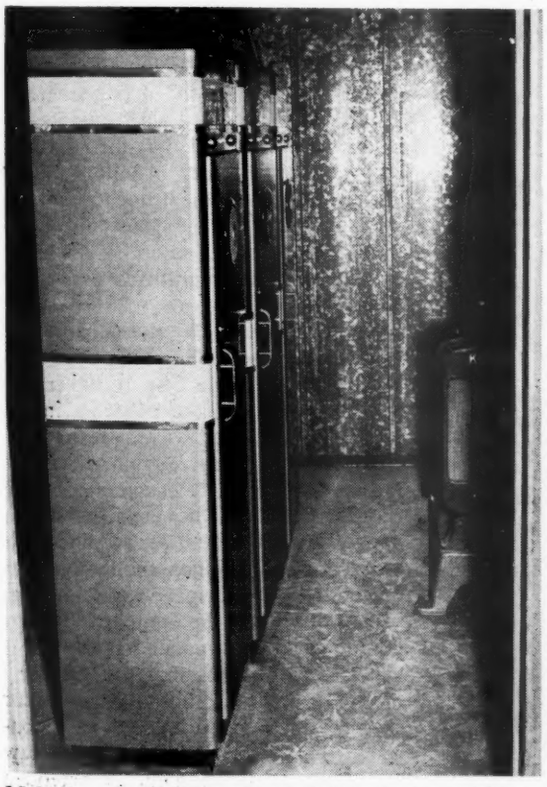
eliminating the local tower and passive reflector.

System Dependability

Probably the most important feature of the microwave system from the user's viewpoint is its dependability. Fortunately, tornadoes do not hit the microwave stations often enough for the survival of the Carlsbad station to be cited as typical of the dependability Pan American has come to expect of its communications circuit. The record is extremely good, however.

During the 18 months preceding March 1, 1953, the system was operating perfectly 95.9 per cent of the time. Only 33 outages occurred over this period and of these all but two were subcarrier failures that affected only part of a single channel. The system was actually out of service for only 9 hours during the 18 months, 0.2 per cent of the time. This record was established without emergency standby equipment.

During the three years since its installation, the microwave system, designed by Motorola, Inc., has become an indispensable link between the



Multiplex and control cabinets inside sheet metal hut at Sterling City station. Gas-driven generator at right starts automatically when REA power is interrupted.

Concho station facilities include microwave multiplex and control cabinets and a VHF cabinet. VHF radio extends communications to cars and trucks in the area.

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necessarily widespread offices and stations concerned with operation of the pipe line. In addition to handling a heavy load of routine messages, the system is always available for emergencies. VHF stations are strategically placed along the microwave system and elsewhere so that the pipe line area is thoroughly blanketed. All company cars and trucks are equipped with VHF units so that key personnel can be reached immediately in an emergency.

Two men each maintain half of the microwave system. They both devote about a day a week to the microwave system and spend the rest of their time working on the other electrical equipment in use on the pipe line, including the VHF equipment.

The low cost of maintenance is perhaps the second most rewarding feature of the system. Pan American, on the basis of three years experience, has broken down the monthly cost of operating its system in the following manner:

Salaries and transportation expense for fieldmen	**$451.00**
Power (Average $20 per station	**160.00**
Tube cost	**37.50**
Component parts cost	**10.00**
Tower upkeep	**3.50**
Tower light cost	**2.00**
Total	**$664.00**

This total reduces to a cost of $4.75 per system mile per month or a cost of $0.95 per circuit mile per month, an extremely low cost for any type of communications equipment.

The microwave system was installed by employees of the Pan American Pipe Line Company with engineering assistance provided by the manfacturer, Motorola, Inc., in initially lining up the circuits and setting the various signal levels. More engineering assistance was provided later by Motorola in making minor modifications, but the most recent additions to the system were made entirely by the personnel of the Pan American Pipe Line Company.

Its three year old system makes Pan American one of the pioneers in the application of microwave, yet the company has encountered none of the hardships normally associated with pioneering. Since its installation, the system has provided dependable service at low cost. When the system was originally laid out, space was allotted at each station for the standby equipment. Performance has so far exceeded expectations that the company now considers additional expense for standby units unjustifiable. The visionaries who, a few years back, foresaw the eventual replacement of extended communication lines by microwave were apparently practical men after all.

* * *

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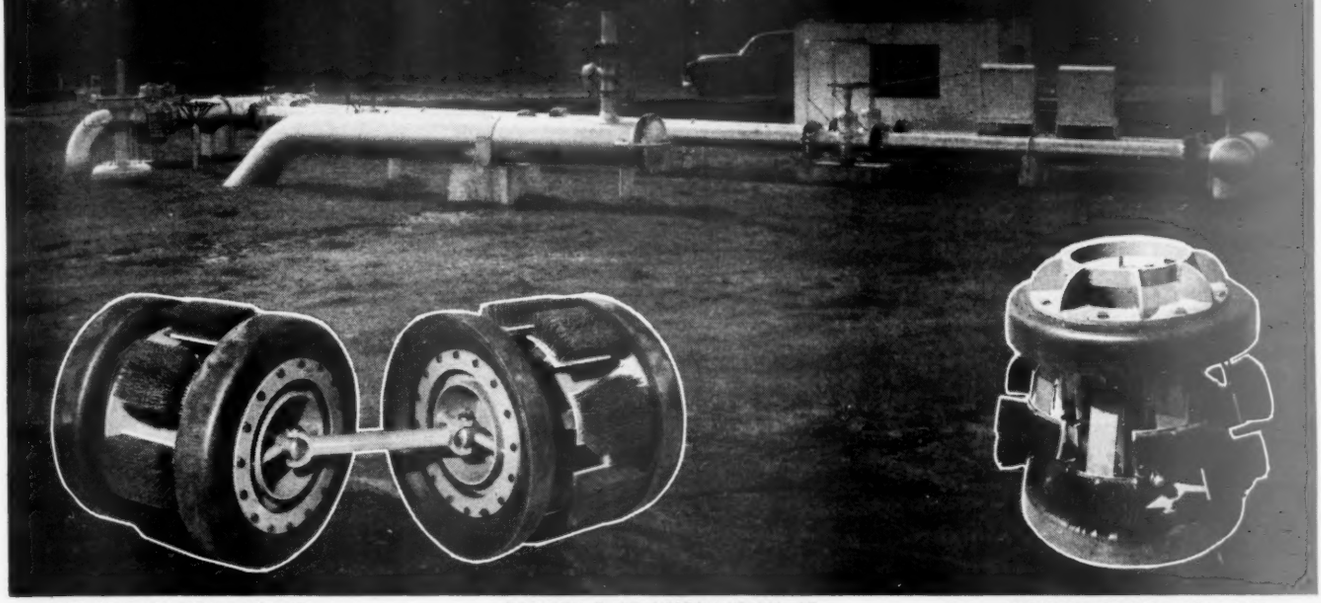

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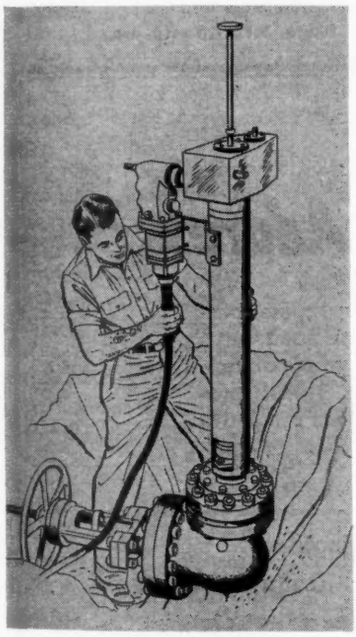

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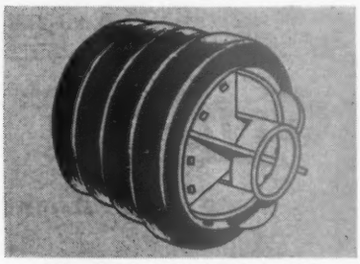

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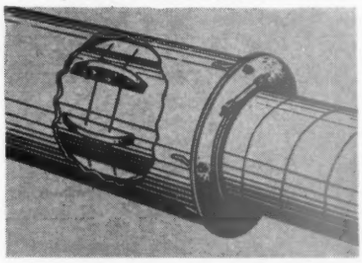

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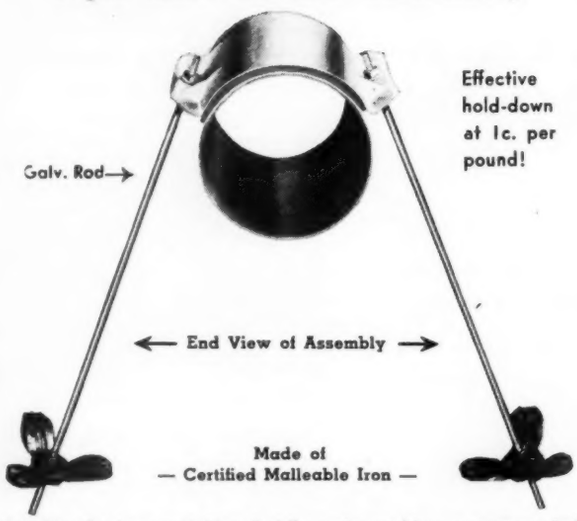

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Supervisory Controls Streamline Operations At Continental's Wichita Falls Station

Results of year's operation prove success of control system at single station pumping on 127-mile line

N. B. MAVRIS

CONTINENTAL Pipe Line Company recently completed one year's operation of its largest crude pipe line. On December 27, 1952, the 127-mile, 12-in. line linking the North Texas district at Wichita Falls with the Ponca City refinery was completed.

Initially, one station located at the Wichita Falls tank farm moves the oil to Oklahoma City. This station was designed to provide economical, efficient operation with a minimum of personnel in attendance. Features of this station that help provide this type of operation are the subject of this article.

Prime movers for the station are high-compression, spark-ignited, supercharged, 9 by 11-in., eight-cylinder gas engines. These engines have a very low fuel consumption. Tests show a consumption of 6100 Btu per bhp per hr for the engines, which means a cost of less than 1 mill per kw-hr for fuel. Main line pumps are 6 by 8-in., 3-stage centrifugal pumps equipped with mechanical seals and are driven through speed increasers having a 6.33:1 ratio.

Other station facilities consist of four 55,000-bbl tanks connected to the station manifold through individual suction and fill lines. Suction pressure for the main pump is provided by in-line, vertical, centrifugal pumps with 25-hp motors.

Pumping Equipment Controls

The station was designed for an ultimate of four units operating in series. Initially, one unit was installed and the second unit is being installed at the present time. Speed of the engines is controlled automatically through the pneumatic output pressure of an auto-selector controller. The controller is actuated by both suction and discharge pressure of the station. Low suction pressure tends to slow the engines down, but with adequate suction pressure, the speed of the engines varies to maintain a preset discharge pressure from the station.

A shutdown sequence arrangement has been designed to allow the cutting-off of units when the speed of the engines has decreased to the point that one unit could adequately handle the load of the station. A selector switch allows the shutting down of any designated unit by reason of minimum speed.

If the load on the station is decreased, the speed of the units decreases to compensate. When a speed has been reached such that a load equivalent to one unit has been removed, one unit will be taken off the line and the others will speed up to meet the required conditions.

As both low suction and high discharge pressure operate to reduce engine speeds, a unit may be removed from the line from either cause, allowing the remaining unit to move the volume involved.

A pressure switch operating on the pneumatic output of the controller has been provided with a setting to close the circuit at the maximum allowable speed of the unit. Its activation sounds the alarm and lights a signal light to identify the necessary adjustment. Shutdown protection from over-speed is mechanically provided in the governor controls, but before shutdown should occur from this cause, this circuit will have identified the approach to the maximum speed limit.

Low-Suction Pressure Alarm

The station is equipped with a low-suction pressure alarm for shutdown. When the suction pressure has dropped sufficiently to approach a dangerous level, an alarm sounds so that the station operator may have an opportunity

The Author

Nicholas B. Mavris is assistant chief engineer for Continental Pipe Line Company. He is a graduate of Oklahoma A. & M., and spent two years in the Armed Forces. After he graduated he joined Interstate Oil Pipe Line Company in 1949, resigning in 1951 to join Continental.

Location of Wichita Falls station, only one on 127-mile line to Oklahoma City. New 12-in. line connects with existing line for continuous movement to Ponca City.

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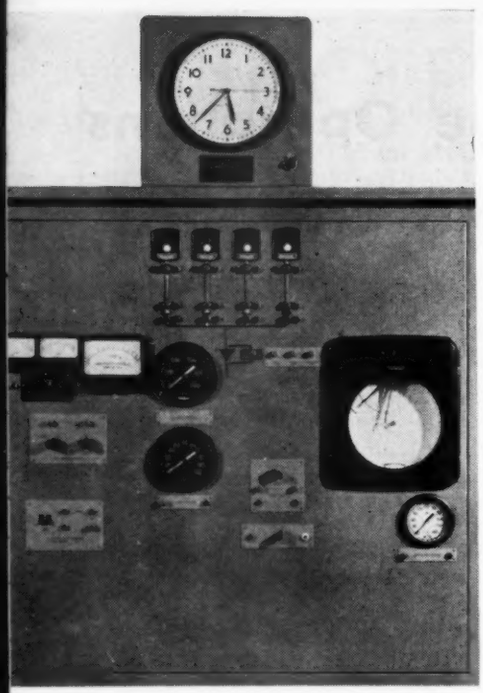

FIG. 1. Control panel, Wichita Falls station.

to investigate, correct what is happening, and possibly avoid a complete shutdown.

If the suction pressure continues to fall, a shutdown sequence on the engine initiated from the control, operated by pneumatic output pressure from the controllers, will shut down all operating engines in order. As the speed controls are pneumatic, it is necessary for their operation that the air supply pressure be continuous. If the air supply pressure should decrease to a preset low limit, a pressure switch would sound an alarm to call the operator for an investigation.

A temperature switch is installed in the engine jacket water outlet for high temperature protection. An increase of jacket water temperature to the switch setting sounds an alarm. The operator may then investigate the cause of the elevated temperature. If the temperature should continue to climb, a shutdown sequence initiated by a control on the engine will shut down the particular unit.

The engine lube oil system is protected by a pressure switch that closes on decrease of pressure to sound an alarm. The lube oil supply is also protected by a temperature switch with an alarm setting in the event of high temperatures.

Incoming Stream Controls

Automatic tank gages are provided with liquid level switches to warn of the oil level in the tanks reaching overflow height. This is connected to the station alarm. Lockout is provided to stop the horn, but the warning light will continue to burn until the level has been decreased to a safe height.

Outgoing Stream Controls

Electrical controls for the motor-operated valves at the manifold and the tank booster pumps are all on the control board, shown in Fig. 1. Motor-operated valves have a manual switch lever on the operators to shift the valve from motor to manual operation. Valves can either be operated manually from individual pushbutton stations or automatically in the booster pump control circuit along with the automatic switching of tanks.

On manual operation, all booster pumps are controlled by pushbutton stations the same way as the motor valves. On manual operation, any combination of booster pumps can be run.

In starting the automatic tank changing sequence, the operation is begun by manually starting the initially selected booster pump and opening the corresponding valve at the manifold. From this operating condition, set up manually, the selector switch (S-5) can then be turned to automatic and the next tank selected to be pumped out can be chosen by the automatic tank selector switch (S-6). The next tank selected is indicated by a white indicator light on the panel.

After the first automatic tank selection has been executed, the tank selector can be switched to a third tank without returning to manual control. While on automatic booster pump control, manual operation of the pushbutton stations on either booster pumps or motor valves is ineffective. Assuming that tank No. 2 has been put on the line manually and that tank No. 1 has been selected to be pumped out next, the following operations would then occur to automatically switch the tanks upon reaching a preset low limit of tank level:

1. The booster pump on tank No. 1 starts.
2. After a suitable time delay, the

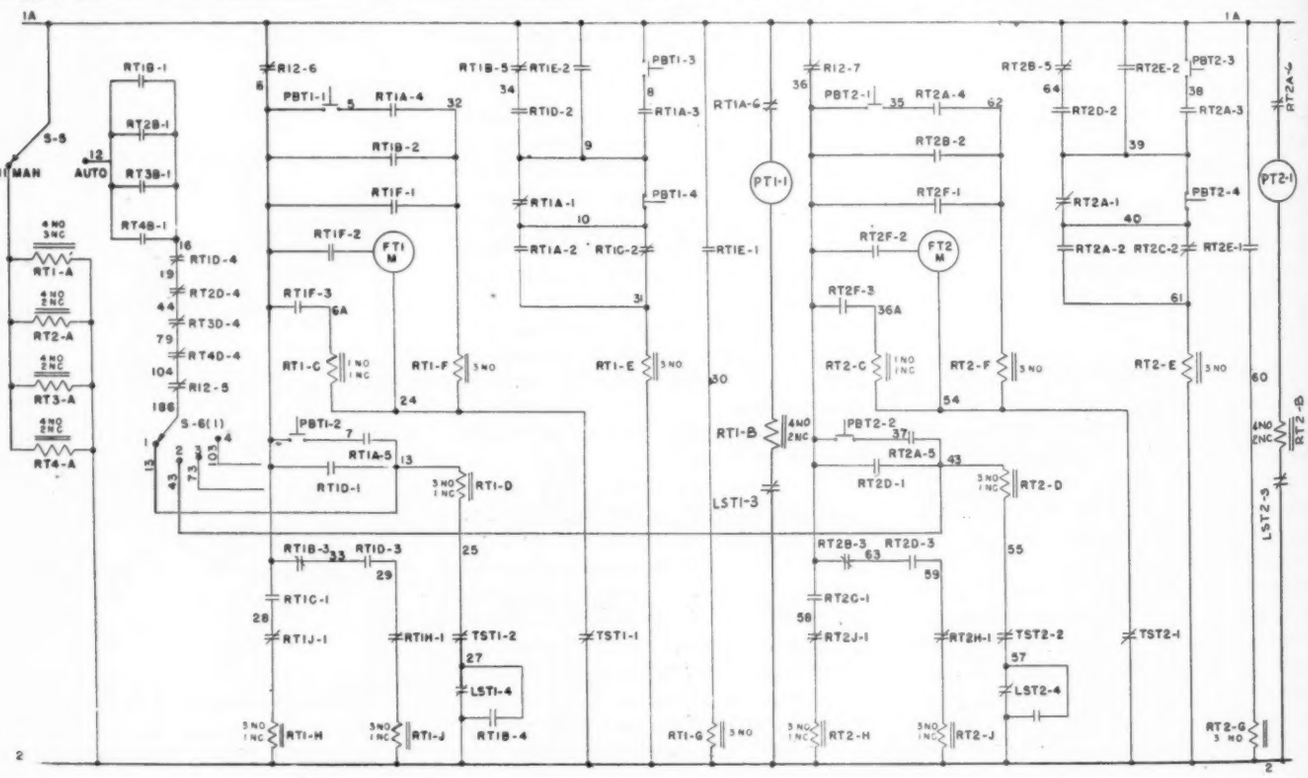

FIG. 2. Schematic diagram of controlling equipment.

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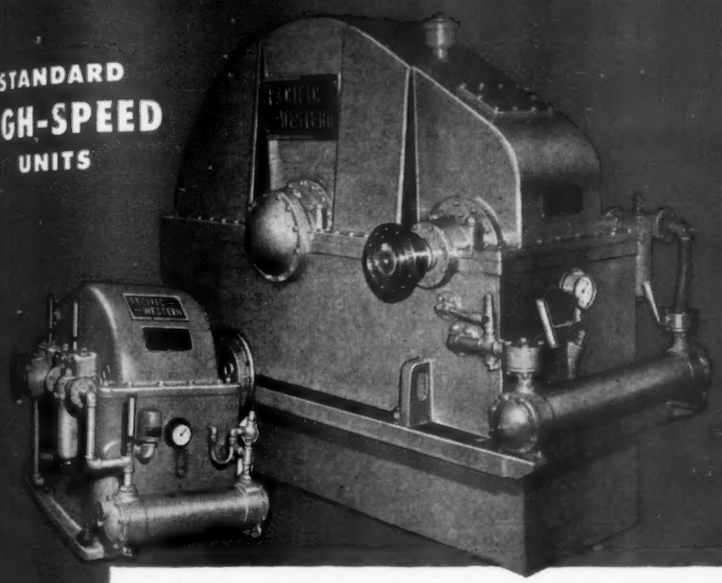

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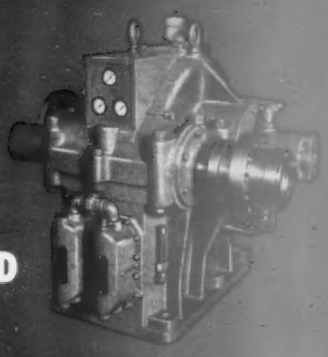

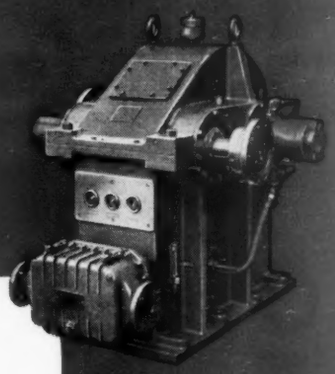

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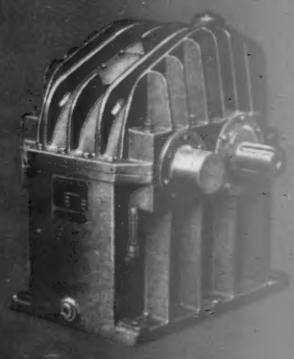

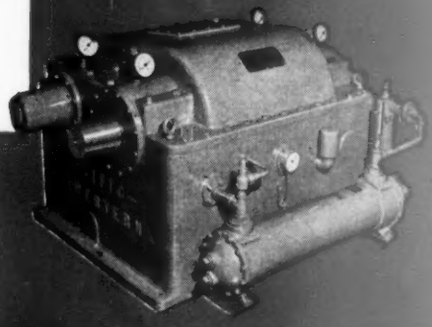

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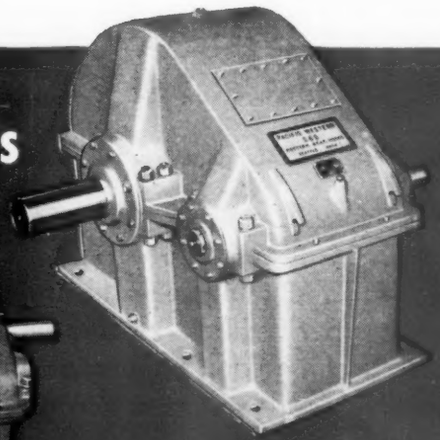

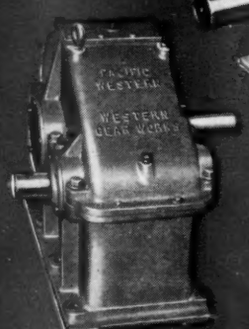

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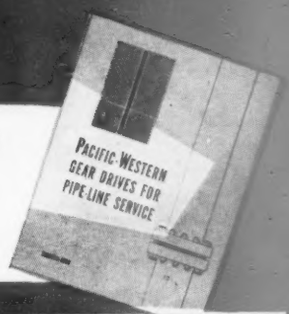

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motor-operated valve on the line to tank No. 1 opens.

3. The booster pump on tank No. 2 stops.
4. The motor-operated valve on the line to tank No. 2 closes.

Referring to the circuit diagram, Fig. 2, these operations, beginning with manually putting the tank and booster on the line and continuing through the automatic switching, would accomplish the following functions:

With S-5 on manual, relays RT 1-A, RT-2A, RT-3A, and RT4-A will be energized closing the following contacts on RT2-A and effecting the indicated functions:

Contact No.	Function
RT2A-1	Open circuit through booster pump motor stop button PBT 2-4
RT2A-2	Closes circuit around breaker contact RT 2C-2
RT2A-3	Closes interruption in circuit to booster start button PBT 2-3
RT2A-4	Closes interruption in circuit to motor valve button PBT 2-1
RT2A-5	Closes interruption in circuit to motor valve open push button PBT 2-2
RT2A-6	Interrupts circuit to low tank level pressure swith PT 2-1

Putting Tank on Line

Putting the tank on the line is accomplished by simply pressing pushbutton station PBT 2-3 which will energize relay RT 2-E closing contacts RT 2E-1, starting booster pump motor, and RT 2E-2, locking in starting relay RT 2-E.

The motor valve on the tank line to No. 2 tank is then opened by pressing pushbutton station PBT 2-2. This energizes relay RT 2-D closing contact, RT 2D-3, to the valve motor starter.

Starting Booster Motor

When the valve has completed its opening travel, limit switch LST 2-4 opens the circuit through relay RT 2-D which opens contact RT 2D-3 interrupting the motor circuit.

Valve operator relays are then deenergized with the valve in the open position and the booster motor is operating, held in by relay RT 2-E with no electrial dependence connection back on the manual or automatic booster pump control switch S-5. The switch can then be shifted from manual to automatic without interferring with any existing operation and by means of tank selector switch S-6 the next tank to come on the line can be selected, say No. 1.

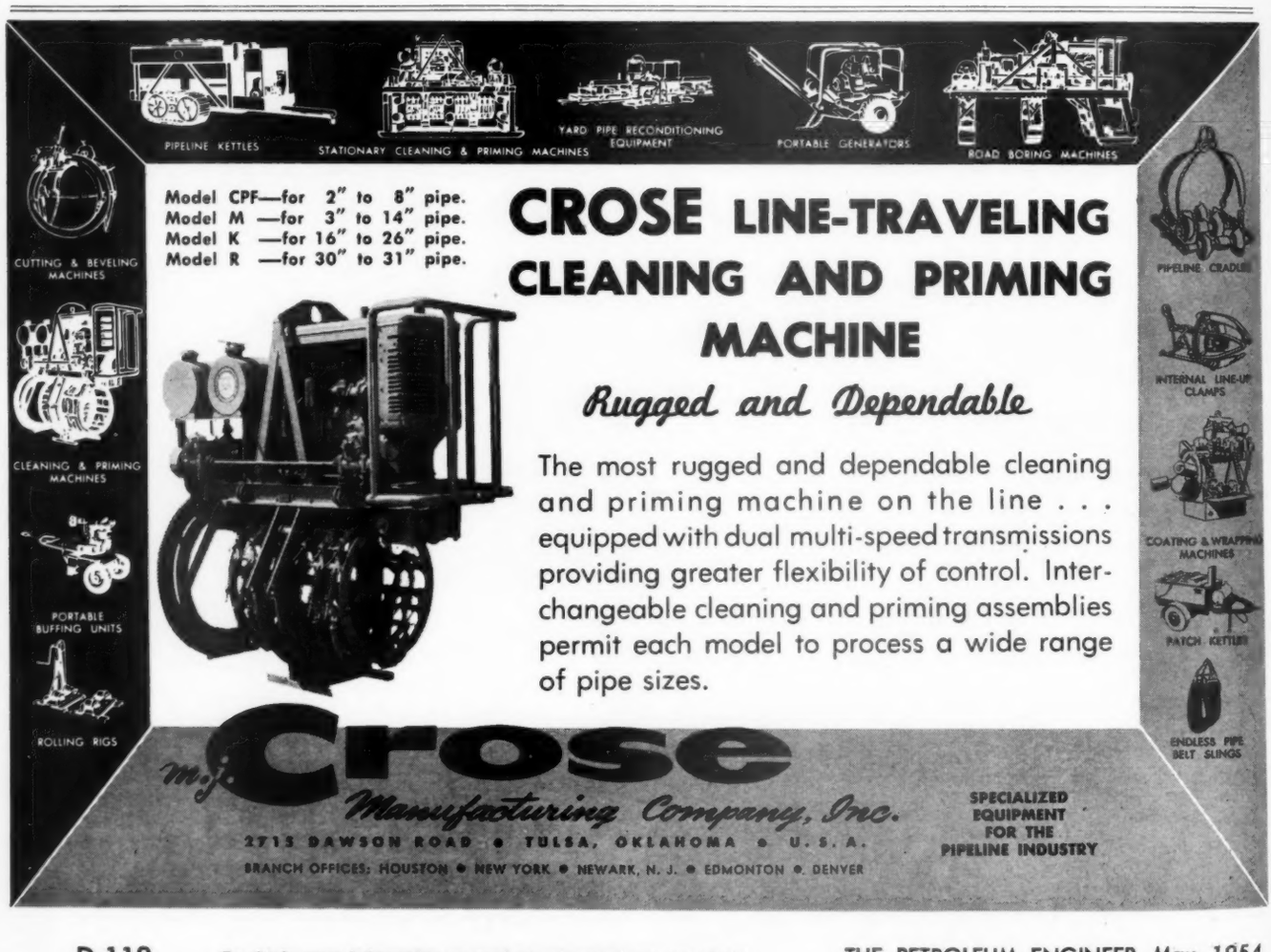
Switching Sequence

The automatic tank switching sequence will then begin when tank No. 2 is pumped down to such level that low level pressure switch PT 2-1 functions, energizing relay RT 2-B, closing contact RT 2B-1, which, through the selector switch, fires relay RT 1-D, contact RT 1-D-1 locks in relay, and contact RT 1-D-4 interrupts the circuit so that additional tanks cannot be thrown on the line by moving selector switch durin the operating cycle.

Energizing relay RT 1-D closes contact RT 1-D-2, which serves to start the booster pump in place of pushbutton PBT 1-3. Also, contact RT 1-D-3 closes to start the motor valve opening.

At the end of the valve opening travel limit switch LST 1-4 interrupts the energized circuit for relay RT 1-D, severing electrical connection with the tank selector switch so that shifting to the next tank selection or back to manual control will not affect the operation of the valve and booster.

Firing of relay RT 2-B at the beginning of this automatic sequence also closes contact RT 2B-1 in the closing sequence of motor valve 2. Relay RT 2-C is a 5-second time delay relay which allows time before the No. 2 valve starts to close for No. 1 motor to come on the line and No. 1 valve to be opened. Relay RT 2-C is locked in by contact RT 2-C-1 and the valve motor starter is energized through contact RT 2-C-2. Contact RT 2-C-3 breaks to shut down No. 2 booster motor. At the end of the valves' closing travel, torque switch TST 2-1 inter-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rupts the circuit de-energizing relay RT 2-C leaving the circuits at rest ready for the next cycle of operation.

Improper Operation Prevented

If selector switch S-6 should accidentally be left on the same tank out of which the station is pumping, say No. 1 as shown on the diagram, contact RT 1-B-4 will close the circuit through relay RT 1-D by shorting out the limit switch LST 1-4, which is open when the valve is in the open position. This allows relay RT 1-D to fire, interrupting the circuit to the selector switch by means of contact RT 1-D-4, but meanwhile relay RT 1-C, fired by contact RT 1-B-2, will have begun the valve closing sequence. Energizing of the valve opening sequence through relay RT 1-D will be prevented by the interruption of the circuit at contact RT 1-B-3. When the motor valve gets to its closed position, the station suction will instantaneously drop to zero and the station controls will shut everything down.

Notification Also Possible

In case operators should desire notification instead of automatic tank switching when a particular tank is pumped down, they can secure this by setting switch S-6 on selector point A (alarm). Energizing of relay RT 2-B then closes contact RT 2-B-1 through Selector Switch S-6 to energize relay R-12. Contact 12-1 locks in relay R-12 and closes the circuit down to relay R-13, and Contact 12-2 sounds inside horns.

Contact 12-3 sounds outside horns or flasher light and Contact 12-4 lights indicator L-6. To silence the inside signal horns, pushbutton PB-6 will then energize Relay R-13, lock it in through contact 13-1, and interrupt the horn circuit by means of contact 13-2.

Many Advantages Provided

Utilization of these supervisory controls provides many advantages: They furnish a protection for the selected items which is more sensitive and faster in detecting trouble than an operator. This means that trouble can be detected, identified, and the equipment shut down before major damage is done.

The controls also keep the output of the station at a pre-selected level, and if the system is running near capacity, the station will maintain a maximum discharge pressure for the operating conditions.

Supervisory controls relieve the operator of constant attendance at the equipment controls, and with the tank switching device will eliminate the time consuming job of checking the tank level as the tank is nearly pumped out.

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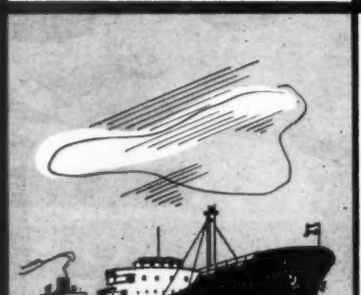

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The What, Why, and How of

Pipe Line Centrifugal Pumps

Theory, design, and application of centrifugal type pumps to uses on pipe lines transporting crude oil and refined petroleum products

C. C. KEANE

THE substantial increase in availability of low-priced electricity following the war has brought into sharp focus electric powered centrifugal pumps.

Rapid strides have been made in the theory, practical design, and application of this type of pumping equipment. The advent of big-inch pipe lines has been responsible for the efforts put forth by designers and manufacturers to satisfy a need which other types of pumps did not meet.

It would be impractical to attempt to cover all of the operating problems and details of pump design in a short discourse. As the centrifugal pump has become such a dominating factor in pipe line transportation, however, features concerning design and details that constitute success in operation may prove of interest.

The two groups of the liquid petroleum transportation industry where centrifugal pumps may be found in substantial numbers today are, of course—the crude oil and refined products pipe lines.

Although the external appearance of a centrifugal pump in either service may show little variation, internally, the impeller configuration generally does not follow the same pattern. An impeller of a centrifugal pump revolving in a casing filled with liquid generates sufficient energy in the liquid to force it radially away from the spinning center. Because liquid offers no resistance in tension, displacement and resulting flow occur.

The theory of maximum performance has been covered in great detail in hydraulic literature by many ably qualified authorities. To provide a motivating interest, however, casual reference will be made to theoretical considerations. In order to prevent confusion in the application of terminology, the following defintions are suggested.

Absolute Velocity

The velocity of the moving water or liquid relative to the earth or to the fixed part of the pump in which the liquid is moving is the Absolute Velocity. If a moving body with a velocity of U (Fig. 1) in any direction is

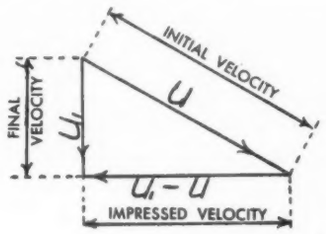

Fig. 1.

changed in any other direction, this change is the vector difference of the initial and final velocities.

Relative Velocity

If two bodies A and B (Fig. 2) are moving with velocities V and V_1, respectively, in given directions, the rela-

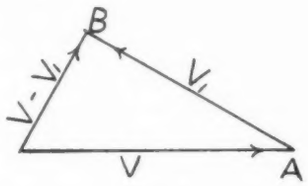

Fig. 2.

tive velocity of A to B is the vector difference of velocities V and V_1. To illustrate: When a moving impeller vane strikes a stream of water, the direction of the relative velocity of the vane and the water is the vector difference of the velocity of the edge of the vane and water where they meet or part.

Angular Momentum

If a weight of W pounds is moving with a velocity U (Fig. 3) in a given direction, the perpendicular distance of which is S feet from a fixed center C, the angular momentum of W is:

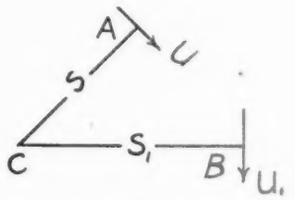

Fig. 3.

$$\frac{W}{g} \times U \times S \text{ pounds feet}$$

Where g = gravity constant.

If after a time "t," the mass is accelerated to U_1, which is perpendicular to distance S_1 from center C, the angular-momentum is now:

$$\frac{W}{g} \times U_1 \times S_1$$

The change in angular-momentum in time "t" is:

$$\frac{W}{g}(U_1S_1 - US)$$

and the rate of change is:

$$\frac{W}{gt}(U_1S_1 - US)$$

Let us consider the work done on the liquid by the impeller. If "R" and "r," Fig. 6, be the radii of the discharge and inlet impeller circumferences, respectively, then the change in angular-momentum as the liquid passes through the impeller is:

$$V_1 \frac{R}{g} \pm \frac{Vr}{g} \text{ per pound of flow,}$$

the plus sign being used when V is in the opposite direction to V_1 as in Figs. 4 and 5.

Neglecting frictional and other losses, the work done by the impeller on the liquid is:

$$\frac{V_1v_1}{g} \pm \frac{Vv}{g} \quad . \quad . \quad . \quad (1)$$

If U is radial, as in Fig. 6, V is zero,

EXCLUSIVE

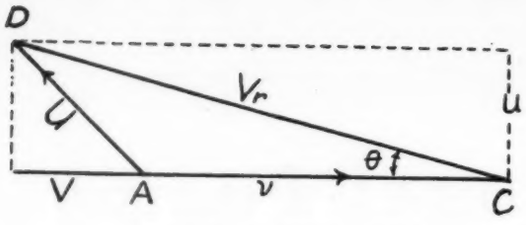

FIG. 4. Inlet velocity triangle.

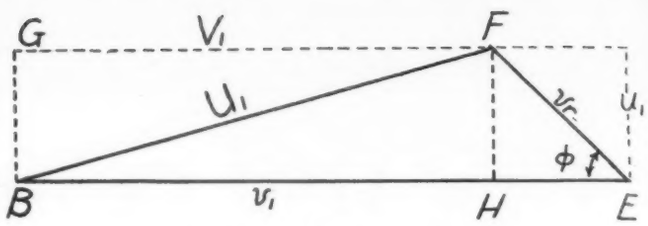

FIG. 5. Exit velocity triangle.

and work done on the liquid by the impeller is:

$$\frac{V_1 v_1}{g} \text{ ft-lb per pound of flow} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

If then, H_o (Fig. 6) is inlet head through which the liquid is lifted, and U_d is the velocity with which it is delivered, then the work done on each pound of liquid is:

$$\frac{U_d^2}{2g} \pm H_o$$

therefore:

$$\frac{V_1 v_1}{g} = \frac{U_d^2}{2g} \pm H_o = H. \quad (3)$$

H_o is negative if inlet is positive and vice versa.

Let $180° - \phi$ be the angle that the direction of the vane at exit makes with the direction of motion, and $180° - \Theta$ the angle that the vane makes with the direction of motion at inlet, then:

$$ACD = \Theta \text{ and } BEF = \phi$$

The Author

Few technical problems relating to operations of a products pipe line have not at some time come under the study of C. C. Keane, chief engineer, Great Lakes Pipe Line Company. The resulting solutions are likely not only to be satisfactory but novel. An adamant foe of the status quo, when there are no new problems of pressing concern, he is usually seeking to improve accepted methods.

Keane was educated and trained in mechanical engineering at Vickers Technology School and Nottingham University in England. After establishing residence in the United States, he traveled extensively for a diesel engine company in the United States, Canada, and Central America, redesigning and modifying power plants, pipe line stations and refrigerator plants. He joined the mechanical department of Prairie Pipe Line Company at Tulsa in 1928. Between 1931 and 1941 he was engaged in several capacities in the operating department of Great Lakes Pipe Line Company until appointed to his present position.

In the triangle HEF, HE = HF Cot ϕ, therefore

$$V_1 = v_1 - u_1 \text{ Cot } \phi \quad . \quad . \quad . \quad (4)$$

the theoretical lift, therefore is:

$$H = \frac{U_d^2}{2g} \pm H_o = \frac{v_1 (v_1 - u_1 \text{ Cot } \phi)}{g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

If Q is the discharge and A_1 the peripheral area of the discharge circumference, then

$$u_1 = \frac{Q}{A_1}$$

and

$$H = \frac{v_1^2 - v_1 \frac{Q}{A_1} \text{ Cot } \phi}{g} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Based on the foregoing, then, if the liquid enters the impeller without shock and all resistances are neglected, the lift is independent of the ratio $\frac{R}{r}$ and depends on the velocity and inclination of the vane at the discharge circumference.

We now analyze the kinetic energy of the liquid at exit from the impeller discharge circumference. Part of the head H, impressed upon the liquid by the rotating impeller, increases the pressure head between inlet and exit. The remainder appears as kinetic energy as it leaves the impeller.

The kinetic energy is equal to:

$$\frac{U_1^2}{g}$$

and it can only be utilized to lift the liquid if the discharge velocity be gradually diminished so as to convert velocity head to pressure head. The conversion is not easily accomplished because swirl or eddy formations introduce considerable loss in the process. If it be assumed that the same proportion of the head, namely,

$$\frac{U_1^2}{g}$$

in all instances is converted to useful work, it is evident that the greater U_1, the greater the loss by swirl formation and the less efficient the pump.

In referring to Fig. 6, the smaller the angle ϕ the greater will be the efficiency, and it has been proved empirically that for a given design of volute casing, the efficiency increases as ϕ is diminished.

Centrifugal Pump Efficiency

The hydraulic efficiency of a centrifugal pump is the ratio of the total work produced by the pump to the input absorbed by impeller assembly.

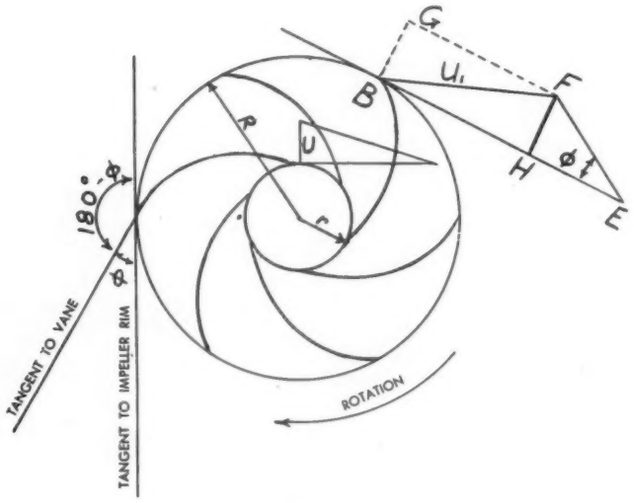

Fig. 6.

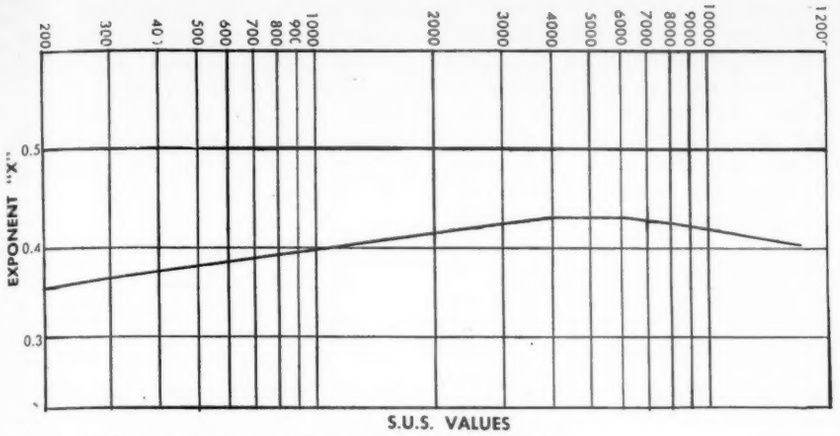

FIG. 7. Values of exponent "x" for given values of SUS.

If W = the weight of liquid lifted per second, and
H = the total head, which = the suction lift, H_o + dynamic head, H_1 + the velocity head at discharge,
the actual lift is:

$$H_a = H_o + H_1$$

If E = the work done on the pump impeller in ft-lb per second and e_h = the hydraulic efficiency, then

$$e_h = \frac{WH}{E}$$

The work done on the pump impeller is less than the work done on the pump shaft by an amount equal to the energy lost by friction in bearings and packing or seal assemblies. The actual efficiency is the ratio of the power produced by the discharge of the pump to the power input by the driving source. If E_s be the input energy to the pump shaft per second and e_m the mechanical efficiency of the pump, then:

$$E = E_s \times e_m$$

and the actual efficiency

$$e_a = \frac{W \times H_a}{E_s}$$

The total efficiency of a pump, which includes mechanical as well as fluid loss, is:

$$e_t = \frac{W \times H_a}{E_s}$$

Experimental Determination of Centrifugal Pump Efficiency

The actual and total efficiencies of a pump may be determined experimentally, but the hydraulic efficiency can only be ascertained when the mechanical efficiency of the pump is known for all loads.

To find the actual efficiency, it is only necessary to measure the height the liquid is lifted, the quantity raised, and the energy E_s delivered to the pump shaft in unit time. A reasonably accurate method of determining the input energy E_s is by using an electric motor drive. With the efficiency of the motor known for varying degrees of current consumption, the load requirements of the pump are readily determined. A transmission dynamometer is more accurate than the motor method, but such equipment is not readily available or applicable to field needs.

We now consider the head impressed on the liquid by the impeller

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and the head against which a pump will commence to discharge. The centrifugal head impressed on a liquid as it passes through an impeller is:

$$H_e = \frac{v_1^2}{2g} - \frac{v^2}{2g}$$

This is the theoretical head that is impressed on the liquid when the impeller is spinning with no flow. Hence it is the difference between the pressure at inlet and outlet when the pump is running against a closed discharge valve. If this is less than $\frac{eV_1v_1}{g}$, the pump theoretically cannot lift against its full head unless it is speeded above its design velocity. The maximum height to which a centrifugal pump raises liquid depends on the maximum velocity at which the impeller perimeter rim may be run.

Assuming radial vanes and a rim velocity of 300 ft per second, with a manometric efficiency of 50 per cent, an impeller under those conditions should lift liquid against 1406 ft of head. Because this is theoretical, and the velocity demands impeller materials with a high resistance to the tensile stresses set up by such rim speeds, its practicality would be exceedingly doubtful.

Other considerations would be a high degree of dynamic balance and a surface hardness that would withstand abrasion from particle impact. Hydraulic losses also would be considerable and manometric efficiencies of greater than 50 per cent should not be expected.

Theory and Practice

Following the brief outline of theoretical considerations, it is highly desirable to determine how these best serve practical field use. While the overall efficiency of a pump has a direct bearing on its operating cost, where appreciable fluctuating load conditions are a constant, efficiency is not a primary requirement. It is a consideration, but the investment to maintain it at a desirable peak might well outweigh the expenditure in power for a less efficient and lower cost unit.

Prior to the introduction of the so-called half unit in large transportation systems, the only method of varying flow rates where constant speed was involved was by throttling the discharge stream. This necessarily increased the power and resulting cost requirement of each barrel pumped. Since it is usual to require that a pump operate at its peak efficiency when running at constant speed without throttling, it is expected that efficiency will drop if the head condition is shifted either side of the peak.

The head capacity curve is greatly influenced by the angle the tangent of the leading edge of the vane makes with the tangent to the impeller rim. This detail should be carefully considered when analyzing flow and pressure conditions. Small angles produce steep head capacity curves, while large ones generate a flat curve over an appreciable range.

The power required to pump viscous oils frequently exceeds that required for water even though the specific gravity of the oil may be less than water. An approximate formula for centrifugal pump power when handling viscous oils is:

$$HP_o = \left\{ \left[\frac{0.90\ HP_w}{M} + \left(\frac{961 \times 10^{-10} \times N^3 \times d^5}{550} \right) \left(\frac{\mu_o}{\mu_n} \right)^X \right] M + 0.10\ HP_w \right\} Sp\ Gr \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Where

HP_o = horse power pumping oil
HP_w = horse power pumping water
M = number of pumping stages
N = revolutions per minute
d = diameter of impeller ins.

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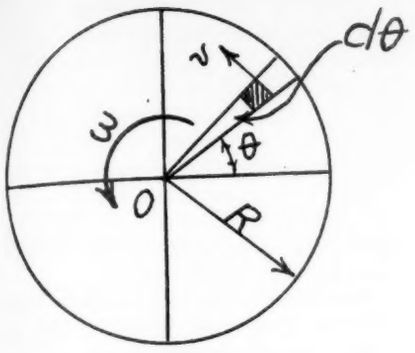

Fig. 8.

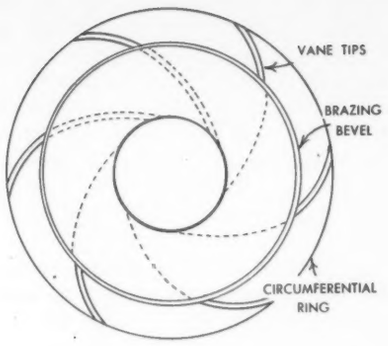

Fig. 9.

$\frac{\mu_o}{\mu_n} = \frac{\mu}{0.01}$ = Ratio of kinematic viscosities oil and water in poises.

Sp. Gr. = specific gravity

To illustrate, a four stage pump with 15-in. impellers, turning at 1750-rpm, pumps 3340 bbl of water per hour against a pressure of 330 psi. If the overall efficiency is 75 per cent, what is the input horsepower?

$$BHP_w = \frac{3340 \times 330}{2450 \times 0.75} = 600$$

If oil of 0.92 sp gr, 1000 SUS is substituted for the water, we can determine the effect of viscosity on the power requirements from Eq. 1.

Convert SUS to kinematic viscosity in poises:

$$\mu = 1000 \times 0.00216 - \frac{1.8}{1000}$$
$$= 2.16 \text{ poises}$$

$$\frac{\mu_o}{\mu_w} = \frac{2.16}{0.01} = 216 \text{ ratio oil to water.}$$

Where

μ_o = kinematic viscosity of oil in poises.

μ_w = kinematic viscosity of water in poises.

The accompanying curve, Fig. 7, shows the values of exponent "x" for given values of SUS.

Using the formula (7), the calculated hp required is:

$$HP = \left\{ 4 \left[\frac{0.90 \times 600}{4} + \left(\frac{961 \times 10^{-10} \times 1750^2 \times 15^5}{550 \times 12^5} \right) (216)^{0.4} \right] + 0.10 \times 600 \right\} \times 0.92 = 635 \text{ HP}$$

This result is 35 hp greater than that for water, although water is 8.7 per cent heavier than the oil. Obviously, impeller disc friction is responsible for the increased load. In this instance, by making proper allowances for specific gravity, the actual power increase by reason of viscosity is:

$$635 - (600 \times .92) = 85 \text{ HP}$$

Since impeller disc friction is a substantial factor in the power consumption of a centrifugal pump, it might be interesting to review theoretical details. Disc friction is not a function of the volume of liquid passing through a pump, hence it is a true mechanical loss.

Theoretically it may be analyzed from the polar diagram Fig. 8.

It is logical to assume the disc friction varies as the wetted area and as the square of the velocity. Therefore the mechanical loss may be deduced as follows:

$$dF = Av^2 da = Ar^2\omega^2 \cdot dr \cdot rd\Theta.$$
$$dL = r\omega \cdot dF$$
$$L = A\omega^3 \int_0^{2\pi} \int_0^R r^4 \, dr d\theta$$
$$= A\omega^3 \int_0^{2\pi} \left[\tfrac{1}{5} r^5 \, d\Theta \right]_0^R$$
$$= 2\pi A\omega^3 \frac{R^5}{5}$$

If A, 2π, and 1/5 are included in a single constant K, together with the relationship between ω and N, and between foot-pounds per second and HP, the power lost in friction on both sides of the impeller is:

$$HP = KD^5N^3$$

Considerable experimental work on disc friction has been done at the University of California. For brass discs varying from 8 to 18-in. in diameter, at speeds from 400 to 2200 rpm, and for clearance dimensions "S" between the side of the disc and its case, the empirical formula shows that:

$$HP = KD^nN^mS^l$$

Where

K = 0.837×10^{-9}

m = 2.88

n = 4.41

l = 0.067

D = diameter disc feet

N = rpm

S = side clearance inches between disc and case.

Selection

In selecting centrifugal pumps for a specific service, it is always desirable to analyze the hydraulic axial equilibrium or lateral balance. Whenever possible loads toward the coupling end should equal loads toward the outboard end. Serious thrust bearing damage may result if this condition is not satisfied within reasonable limits.

Details surrounding the installation of centrifugal pumps have become more complex as units have increased in size. Experience has shown that certain accessories are essential such as spacer type couplings, mounting bases of heavy sectional structure where stiffness and rigidity are a factor and where diesel engines are used, foundations for pump, gear, and engine should be carried on a heavily reinforced concrete mat.

Installation

After alignment of the power and pump assemblies, shaft couplings should be left open until grouting is set and foundation bolts are tight. Conventional dial indicators are generally used to check alignments; however, for long assemblies such as engine, step-up gear and pump, the optical system now used by the aviation industry provides an excellent means of checking vertical and horizontal eccentricity.

A stress that frequently causes substantial distortion of pump cases and is responsible for excessive bearing heat and coupling wear, stems from suction and discharge piping misalignment. Maintenance personnel should check this feature as diligently as other details when inspecting machinery for mechanical disturbances.

Vibrations

Dynamic unbalance in impeller and electric motor rotor assemblies may and do cause considerable bearing damage, if the condition causing it is not corrected. Vibration from this source which is radial should not be confused with torsional vibration, which is an oscillatory torque that becomes dangerous when its natural frequency or a harmonic of this coincides with the rhythmic power pulse of the powering unit.

There are several practical dynamic balancing analyzers on the market today, which, if intelligently used, will save many hours of breakdown repairs. The pioneer designs utilized a light source in a vibrating pickup head to show the amplitude of the vibration. A

small neon flasher combined with phase shifter and stroboscopic light indicate the position of the mass causing the unbalance.

Torsional vibration generally originates in engine, gear and pump assemblies. The mathematical approach to a detailed analysis is quite complex; hence, only casual reference will be made to the problem here. It is essential however, that such an analysis be made prior to the purchase of the equipment.

No damaging critical speeds should fall within the operating range of engine and pump assemblies. Flexible couplings that dampen torsional oscillations are particularly desirable and if the torsional resiliency of the coupling has great enough spread, the engine and pump may be regarded as single mass systems although actually multi-mass in character.

Cavitation

Still another cause of vibration occasionally arises from the hydraulic performance of a pump. It is known as cavitation and is frequently listed as the cause of vabriation from hydraulic sources; yet this is not always essentially correct.

Vibration may be generated by a sympathetic harmonic of low amplitude and high frequency that in turn causes a rhythmic beat of the metal rotating parts. As the liquid in the pump may be unable to follow the frequency of vibrating parts, there is a continuous generation and destruction of small vapor-filled cavities. Pitting of impeller rim tips and sections of volute chambers result from cavitation caused by vibration.

Petroleum oils present a complicated example of cavitation. As they are mixtures of a multitude of individual hydrocarbons, each of which has its own vapor pressure, low boiling point materials will vaporize at pressures far above their normal distillation figure.

Cavitation may be reduced appreciably if the following suggestions and recommendations are given weight and consideration.

1. **Eliminate suction line losses and avoid use of abrupt turns, miter welds and restricting runs of pipe. Provide the largest diameter suction line that may be practically used.**

2. **If the pump is high in specific speed, it should have sufficient number of vanes in the impeller to reduce the mass of liquid in each passage. In low specific speed pumps liberal eye area at inlet and a minimum number of impeller vanes prevent cavitation.**

3. **The NPSH (net positive suction head) should be as low as is practical and the available suction head should be determined for the worst condition. The pump manufacturer should be apprised of this and should thoroughly understand the necessity of the pump performing at the NPSH that is guaranteed. The problem of cavitation is reasonably well understood today, and proper precautions at the outset of an installation will usually prevent its occurrence.**

Increasing Head Capacity

A final word on field methods to change the head-capacity of pumps operating at constant speed. Slight deficiencies in head may be corrected by filing to a gentle slope the trailing edge of the impeller vane. This increases the angle between the tangent to the vane and that to the impeller rim, thereby increasing the tangential component of the absolute velocity.

Another method of increasing head capacity of constant speed pumps within their case limitations may be accomplished by silver brazing circumferential rings to the outside of impellers which are reduced in diameter. For example, a 12-in. diameter impeller may be increased to 13½-in., if the pump case and power unit are adequate, by the attachment of such rings. Since:

$$H' = H\left(\frac{Di}{D}\right)^2$$

Where

H' = New head
H = Old head
D = Old diam. = 12″
D_1 = New diam. = 13.5″

Then, the new head is 26 per cent greater than the old (and the new volume at that head is 12 per cent more than the old. Also the power required is 42 per cent above the original.

A sketch of the method of attachment is shown in Fig. 9.

In conclusion, with the increased efficiency of internal combustion turbines, no better assembly appears in the pump field than this prime mover when coupled to a centrifugal pump. The speeds of today will soon be history when metals capable of withstanding the high rim stress of 10,000 to 15,000 rpm are available. * * *

References

1. "Centrifugal and Axial Floor Pumps," by Stepanoff.
2. "Hydraulics," Le Conte.

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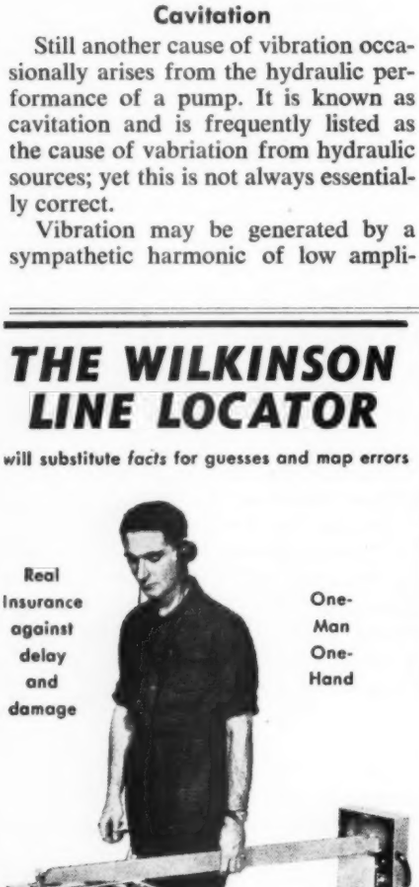

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FOLKS who know Jim Neill say he doesn't take out just one card when he comes calling — he pulls out a deck of 52 and invites you to join him in a friendly game of gin rummy.

Gin rummy, however, is just a spare-time diversion for the native Pennsylvanian who prefers to think of himself as a Californian living in Texas. Building pipe lines is the other big interest, an interest backed by many years of experience laying line in "rugged country."

Born in Sewickley, Pennsylvania, Jim's education began with eight years of elementary school in that state, followed by four years of high school at Santa Monica, California, and schooling at Stanford University.

In 1928, he entered pipe line construction with Williams Brothers, on a line for Colorado-Interstate Natural Gas Company, working his way up to foreman. After completion of the line, he transferred to the Canadian River Gas Company, building its Bivens Compressor station. Following that work, he worked on the Mississippi River crossing for Memphis Natural Gas Company and later was in charge of a construction gang of Louisiana Interstate Natural Gas Company on loop line projects.

He joined Southern Natural Gas Corporation as district engineer in 1929, where his work embodied all phases of inspection and direction of pipe line construction in Louisiana. His responsibility was increased with his promotion to division engineer in Alabama, where he supervised the construction of main and branch transmission lines.

Following the completion of construction work, Jim was appointed division superintendent and was later district foreman in charge of general maintenance over 217 miles of the transmission system. In 1935 he became superintendent of pipe lines, in charge of operations and maintenance of 1500 miles of pipe line servicing the southeastern states.

In 1944, the affable pipeliner left Southern Natural for a new executive post with the H. C. Price Company of Bartlesville, Oklahoma, his 15 years of experience in pipe line construction and operation well qualified him for the post of general superintendent of the contracting company. Jim later became executive vice president of the Price company and helped build the first 30-in. natural gas transmission line ever constructed.

JAMES P. NEILL

President

Western Pipe Line Constructors

In 1950 he resigned his position with the Price firm to form Western Pipe Line Constructors. First job for the new firm was 185 miles of 30-in. for Texas-Illinois, a gas pipe line. During 1951-52, Western constructed lines for Columbia Gas System in West Virginia, working in mountainous and rough terrain.

During 1952, the company built 127 miles of 30-in. for Tennessee Gas Transmission Company in Kentucky and Tennessee, encountering bad rock on most of the line route. In 1953, Western built a 170-mile section of El Paso Natural Gas Company's 30-in. Midland, Texas, to Needles, California pipe line. Western's section was across the Rocky Mountains in Arizona.

To Jim Neill, pipelining is a profession, not just a trade, and he was instrumental in starting the Pipe Line Contractors Association. Helping to build the PLCA since its inception, he has also served as president, vice president, and director of the organization.

Building pipe lines with comparative ease in the rough country where most folks don't care to venture has become somewhat of a trademark with Western Pipe Line Constructors. Much of the success in such ventures can be attributed to a friendly, capable, and efficient fellow named Jim Neill.

PIPE LINE DEVELOPMENTS

Name of Company	Miles	Pipe size, in.	Location	Contractor
CRUDE LINES				
California-Oregon Pipe Line System	103	6	Crescent City, California to Medford, Oregon.	Proposed
Cities Service Pipe Line	60	12	Houston to Sour Lake, Texas.	O. R. Barden Constr. Company
Gulf Refining	55	12	Bay Marchand to Plaquemines, Louisiana.	Planned
Humble Pipe Line C.	32	10	Kingsville to Corpus Christi, Texas.	H. S. Shanks and H. H. Null, Inc.
Interprovincial Pipe Line Co.	129	24	Edmonton to Alberta-Saskatchewan Border	Mannix, Ltd.
Interprovincial Pipe Line Co.	124	24	Alberta-Saskatchewan Border to South Saskatchewan River	Fulton-Banister Construction Company
Interprovincial Pipe Line Co.	201	24	South Saskatchewan River to Gretna, Manitoba.	Anderson International
Lakehead Pipe Line Co.	153	26	Loops on present line	R. H. Fulton& Company
Lakehead Pipe Line Co.	51	26	Loops on present line	Anderson Brothers
Magnolia Pipe Line Co.	20	8	Midland County, Tex. area	Planned
Magnolia Pipe Line Company	208	20	Corsicana to Beaumont, Texas	H. B. Zachry
Michi, Incorporated		10	Highland, Ind., to Kalamazoo, Alma, and Elsie, Mich.	Planned
Minnesota Pipe Line Co.	250	16	Clearbrook to Hastings, Minnesota.	Planned
Mid-Saskatchewan Pipelines, Ltd.	24	8	Smiley Kerrobert, Saskatchewan, Canada.	Planned
NNCW Pipe Line Co.	127	8–10	Weston County to Casper, Wyoming.	Planned
Orchard Pipe Line	45	8	Orchard to Merino, Colorado.	Proposed
Omaha-Denver Express Company	65	—	Little Beaverfield to Denver, Colorado	Proposed
Pawnee Pipe Line	35	10	Adena field and Merino, Colorado.	Proposed
Powder River Pipe Line Company	52	6–8	Gathering lines, near Kaysee, Wyoming.	Planned
Progress Pacific Pipeline Company	1100	24	Odessa, Texas, to Los Angeles, Harbor, Cal.	Planned
Proven Oil & Refining Company	32	8	Connection with West Coast Pipe Line to Florence, Ariz.	Planned
Roosevelt Oil & Refining Corp.	22	4, 6	St. Helen to Norwick, Michigan.	Planned
Service Pipe Line Company	55	4–6–8	Tioga-Beaver Lodge area gathering system.	C. P. Bartley & Son
Sinclair Pipe Line Company	10	12	Pauls Valley to Bradshaw Gate Plant, Okla. (Loop).	Planned
Sioux Pipe Line System	1000	16 to 24	Williston Basin to Chicago.	Under consideration
Texas New Mexico Pipe Line Company	52	10	Dawson County to Basin System.	McVean & Barlow
Texas Pipe Line Co.	34	6	Sour Lake to Port Arthur, Tex.	Houston Contracting
Texas Pipe Line Co.	45	8–10	Erath and Bayou Sale sta.	Houston Contracting
Trans Mountain Oil Pipe Line Corp.	26	16–20	Canadian border to Ferndale, Washington.	Planned
Trans Mountain Oil Pipe Line Corp.	27	20	Laurel Junction to Mt. Vernon, Washington.	Planned for 1955
Union Oil Company	60	—	Santa Clara Field to Wilmington Refinery.	Planned
West Coast Pipe Line Company	960	20–22	Wink, Texas to Norwalk, California.	Planned
PRODUCTS LINES				
American Pipe Line Company	1910	8 to 26	Beaumont, Tex., to Newark, New Jersey, with laterals.	Proposed
Augusta Pipe Line Company	43	8	Arkansas City to Augusta, Kansas.	Ray L. Smith & Son, Inc.
Badger Pipe Line Company	215	8–10–12	East Chicago, Indiana to Madison, Wisconsin.	Begin Spring '54.
Bell Oil & Gas Co.	150	6–8	Ardmore to Drumright, Okla.	Proposed
H. W. Bass & Sons, Incorporated	152	4–6	Duval and Live Oak Counties, Texas, to Corpus Christi, Texas.	Proposed
Great Lakes Pipe Line Co.	132	8	Nebraska City to Doniphan, Nebraska	R. H. Fulton & Company
Great Lakes Pipe Line Co.	150	8	Iowa City, Iowa, to Prophetstown, Illinois.	Planned
Great Lakes Pipe Line Co.	—	8–12	Loop on existing Minneapolis to Willmar, Minn. line.	Planned
Great Lakes Pipe Line Co.	—	12	Loop on Kansas City-Des Moines lines.	Planned
International Pipe Line Inc.	132	8	Wrenshall to Minneapolis, Minnesota.	Proposed
Oil Basin Pipe Line Company	230	8	Laurel, Billings to Glendive, Montana.	Planned
Oklahoma Mississippi River Products Line,	475	12	West Memphis, Arkansas to White River.	Williams Bros.
Oklahoma Mississippi River Products Line,			White River to Duncan Oklahoma.	River Construction Co.
Phillips Petroleum Company	54	6	Goldsmith to Borger, Texas.	Planned
	52	10	Shell's Brookshire system to Sweeney, Texas.	Planned
Shamrock Oil & Gas Corporation	55	6	McKee to Amarillo, Texas.	Planned
Shell Pipe Line Corporation	65	12	Baton Rouge, Louisiana to Norco Refinery.	Houston Contracting Company
Sunflower Pipe Line Company	265	3–6	Kearny, Grant and Haskell counties to Wichita, Kan.	Planned
Triangle Pipe Line Company	560	12	Arkansas City, Arkansas, to Covington, Kentucky, and Nashville, Tennessee.	Proposed
United States and Canadian Govts.	600	8	Haines to Fairbanks, Alaska.	Underway
U. S. Army	600	—	Network of products lines in Spain to serve military bases.	Planned

Name of Company	Miles	Pipe size, in.	Location	Contractor
United States Pipe Line Company	1799	22–26	Beaumont, Texas to Newark, New Jersey.	Proposed
Williston Basin Pipe Line Company	244	8	Laurel-Billings, Montana refineries to Glendive, Mont.	Proposed
Wyoming-Nebraska Pipeline Company	215	6	Cheyenne, Wyoming, to North Platte, Nebraska.	Engineering underway
Yellowstone Pipe Line Company	540	10	Billings, Mont., to Spokane, Wash.	To be completed 9-54.
GAS LINES				
American-Louisiana Pipe Line Company	1000	30	Lowry, Louisiana to Detroit, Michigan.	Proposed
Arkansas-Louisiana Gas Company	107	8⅝ to 24	Nine Loops on System.	Planned
Arkansas-Missouri Power Company	140	2 to 10	St. Francis River, Clay County, Ark. to Campbell, Mo.	Planned
Associated Natural Gas Company	88		Missouri.	Proposed
Atlantic Seaboard Corporation	29	26	Looping along Cobb-Rockville, Maryland, line.	Pipe Line Construction & Drilling Company
Buzzard Bay Gas Company	28	8	Bourne Bridge to Hyannis, Massachussetts.	Hallen Company
Chicago District Pipe Line Company	31	20–30	Chicago area.	Proposed
Cities Service Gas Company	18	16	Lawrence and Newton Counties, Missouri.	
Cities Service Gas Company	24	26	Franklin and Johnson counties, Missouri.	Planned
Cities Service Gas Company	9	20	Cherokee and Jasper counties, Missouri.	Planned
City of Fayette, Alabama	20	5	Fayette, Ala. to Southern Natural's system.	Proposed
City of Dallas, Georgia		8, 4½	Distribution system.	Engineering-Construction Company, 1954.
Coast Counties Gas & Electric Company	40	3, 4, & 8	Coast and Valley Region, California.	Planned
Colorado Interstate Gas Company	365	22	Green River, Wyoming to Denver, Colorado.	Planned
Colorado Interstate Gas Company	243	4 to 20	Colorado, Oklahoma, Texas, and Kansas.	Engineering-Construction and Z. J. Graham
Colorado-Western Pipeline Company	454	—	S. W. Colorado fields to Denver area.	Planned
Colorado-Western Pipeline Co.	328	16–18	Ignacio field to Pueblo and Denver	Proposed
Continental Oil Company, (Agent)	—	—	Gas gathering system in Washington and Adams counties, Colorado.	Planned by operators of Little Beaver and Badger Creek fields
Cumberland and Allegheny Gas Co.	31	12	Garrett County, Maryland, to Keyser, West Virginia.	Proposed
El Paso Natural Gas Company	13.3	—	Lea county, New Mexico.	Planned
El Paso Natural Gas Company	32.5	10	Reagan county to Upton County, Texas.	Planned
Fort Worth Basin Gas Company	—	—	Novice, through Brown and Comanche Counties, Tex.	Planned
Glacier Gas Company	285	20	Kalispell, Montana, to Spokane, Washington.	Proposed
Glacier Gas Company	120	16	Spokane to Hansford, Wash.	Proposed
Glacier Gas Company	91	8⅝	Spokane to Lewiston, Idaho.	Proposed
Glacier Gas Company	130	12¾	Spokane to International boundary at Trail, British Columbia.	Proposed
Gulf Interstate Gas Company	860	30	Acadia Parish, Louisiana, to Boyd County, Kentucky.	H. C. Price and Houston Contracting. 11–54
Gulf Interstate Gas Company	230		Gathering lines.	Associated Pipe Line Contractors. Anderson Bros., Williams Bros.
Gulf Interstate Gas Company	329	12–24	Laterals off Acadia Parish, Louisiana, to Boyd County, Kentucky, line.	Proposed
Home Gas Company	32	12	Breesport to Union Center, New York.	Planned
Home Gas Company	22	12–16	Binghampton, New York.	Under way
Houston Texas Gas and Oil Co.	1600	30	East Texas to Minnesota.	Proposed
Houston Texas Gas and Oil Co.	1600	30	South Louisiana to New York.	Proposed
Interstate Power Company	26	8	Hooppole, Illinois to Clinton, Iowa	Proposed
Iroquois Gas Corp.	24½	20	Erie County, New York	Proposed
Kansas-Nebraska Natural Gas	41	10	Albion, Arcadia, and Broken Bow, Nebraska.	Proposed
Kansas-Nebraska Natural Gas	37	2–3	Gathering lines in Colorado.	Planned
Kansas-Nebraska Natural Gas	66	—	Gathering lines in Denver-Julesburg area.	Planned
Kansas-Nebraska Natural Gas	40	—	Gathering lines in Hugoton field in Kansas.	Planned
Kansas-Nebraska Natural Gas	13	—	Gathering lines in Guymon field of Oklahoma.	Planned
Lateral Gas Pipe Line Co.	27	—	Grant, Clarinda and Villisca, Iowa.	Planned
Lone Star Gas	100		Proposed storage fields to Dallas-Ft. Worth area.	Proposed
Lone Star Gas	35	12	Southeastern Schleicher County.	Proposed
Lone Star Gas	36	12	Stamford to Abilene, Tex.	Planned
Lone Star Gas	44	12	Red Springs, Woods County to Sulphur Springs area, Hopkins County, Texas.	Under way
Manufacturers Gas Light & Heat	40		Allegheny, Washington, and Beaver Counties, Pa.	Proposed
Manufacturers Gas Light & Heat	213	3 to 16	Various points on system in Pa., West Vir. and Ohio.	Proposed
Manufacturers Gas Light & Heat	72	16–20	Doddridge, Wetzel and Marshall Counties, West Vir.	Proposed

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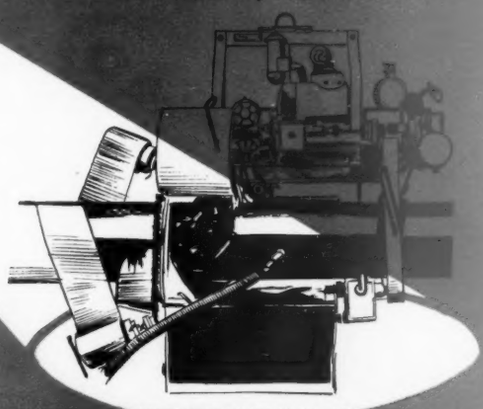

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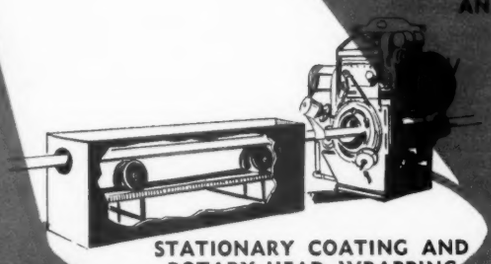

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PIPE LINE DEVELOPMENTS

Name of Company	Miles	Pipe size, in.	Location	Contractor
Michigan Consolidated Gas Company	25.5	12	Sparta to Muskegon, Michigan.	Planned
Michigan-Wisconsin Pipe Line Company	252	4–24	Loops and stations in Illinois.	Planned
Mississippi River Fuel Corporation	190	10–18	Laterals in Woodlawn and Waskom gas fields, Tex.	Planned
Missouri Central Gas	25	6	Moberly to Macon, Mo.	L. R. Young Construction
Missouri Public Service	24	10	New Franklin to Trenton, Missouri.	Proposed
Missouri Public Service	24	10	Johnson County to Clinton, Missouri.	
Montana-Dakota Utilities Co.	4	—	Lines and 2640 hp station in Big Horn County, Mont.	Planned
Montana Power	52	16	Canada-Montana border to Cut Bank, Montana.	Planned
Morganfield Natural Gas	31	4–6	Through Sturgis, Providence. Clay, Diamond, Wheatcroft and Sullivan, Kentucky.	Planned
Natural Gas Pipe Line Co. of America	240	24	Cater, Garvin and Stephens counties to Hutchinson county, Texas.	Planned
Natural Gas Producer, Inc.	100	12	Yenter pool to Denver, Colorado.	Planned
New River Gas	50		Summers to Monroe counties, West Vir.	Planned
North Dakota Natural Gas Company	500	10–12	Statewide system in North Dakota.	Planned
Northeastern Gas Transmission	22	8	Upton, Massachusetts to Pawtucket, Rhode Island.	Planned
Northern Indiana Fuel & Light	35	8	Edgerton to Alburn, Indiana.	Planned
Northern Natural Gas Co.	189.2	30	Loops in Tex., Okla., Kan., Neb., Iowa and Minn.	Midwestern Constructors
Northern Natural Gas Co.	150	—	Branch and gathering lines on system.	Planned
Northwest Alabama Gas District	40	9	Southern Natural's line to Haleyville, Alabama.	Certified
Northwest Natural Gas Co.	665	18–24	Northern Idaho and Eastern Washington.	Proposed (Revised plans)
Northwest Utilities Ltd.	42	—	Bonnie Glen to Edmonton	Planned
Ohio Fuel Gas	31	20	Licking County to Richland County, Ohio.	Planned
Ohio Fuel Gas	22	16	Dayton, Troy, Piqua and Sidney, Ohio.	Planned
Ohio Fuel Gas	23	16–20	Wellington to Elyria, Ohio.	Planned
Ohio Fuel Gas	16	20	Benton Station to Crawford Station.	Planned
Ohio Fuel Gas	18	20	Crawford Station to near Columbus.	
Ohio Fuel Gas	16	16	Berlin to Sandusky, Ohio.	Planned
Ohio Fuel Gas	74	3 to 20	Hocking, Knox, and Ashland counties, Ohio.	Planned
Ohio Fuel Gas	47	20	Benton Township, Hocking County, to Columbus, Ohio.	Planned
Ohio Fuel Gas	61		Northern and southwestern Ohio.	Planned
Ohio Fuel Gas	33	20	Jefferson to Seneca, Ohio.	Proposed
Ohio Fuel Gas	69	20–24	Lines to tie in Gulf Interstate line along various points in Ohio.	Proposed
Pacific Gas & Electric	50	12-16-20	Fresno to Merced, Cal.	Planned
Pacific Gas & Electric		20	Holm to Topock-Milpitas line—Section 2.	
Pacific Gas & Electric		12	Section 3—Parallel existing Madera Livingston line.	Planned
Pacific Gas & Electric	129	31	Main-line loops along Topock, Arizona, to Milpitas, California.	Completion date 11-54 Proposed
Pacific Northwest Pipeline Corp.	1466		Ignacio, Colorado, to Bellingham, Washington.	Proposed
Pacific Northwest Pipeline Corp.	380		Laterals and spurs off mail line to Pocatello, Idaho to Yakima, Washington.	Proposed
Panhandle Eastern Pipe Line Co.	125	—	Tuscola, Ill. to Mich.-Wis. Pipe Line connection.	Planned
Permian Basin Pipeline Company	280	16–24–26–30	West Texas and New Mexico.	R. H. Fulton & Company
Pine Tree Natural Gas Co.	204	—	Boston to Bangor, Maine.	Planned
Rockland Light & Power Company	22	8	Orangetown to Tompkins Cover, New York.	Proposed
Shenandoah Gas Company	39	3-4-8	Middleton Virginia, to Martinsburg, West Vir.	Proposed
Signal Oil and Gas Company	70	4–22	Gathering lines near Ardmore, Oklahoma.	Groninger & King
South Georgia Natural Gas Company	339	2–12	Phoenix, Alabama to Tallahassee, Florida.	Planned
Southern Natural Gas Co.	250	18	Loops on southern line.	Planned
Southwest Gas Corporation, Limited	26	—	From P.G. & E. line to Victorville, California.	Proposed
Tennessee Gas Transmission	243	24	Hebron, Pennsylvania to Greenwich, Connecticut.	Planned
Tennessee Gas Transmission	28	30	White Plains, New York to Newark, New Jersey.	Planned
Tennessee Gas Transmission	571	30	Kinder, Louisiana to Portland, Tennessee.	Approved
Tennessee Gas Transmission	67	30	Loops in Texas and Louisiana.	Approved
Tennessee Gas Transmission	63	26	Loops in Ohio and Pennsylvania.	Approved
Tennessee Gas Transmission	58	20	Louisiana Gulf Coast to near Kinder, Louisiana.	Approved
Tennessee Gas Transmission	100		Laterals In Texas.	
Tennessee Gas Transmission	45	20	Buffalo, New York to the U. S.-Canadian border, Hamburg station near St. Catherines.	Approved
Texas Eastern Penn-Jersey Transmission Corporation	265	24	Oakford storage field to Lambertville, New Jersey.	Planned
Texas Gas Transmission Corporation	48	26	Loops on Memphis-Slaughter line.	Planned
Texas Gas Transmission Corporation	24	16	South Louisiana gas fields.	Planned
Transcontinental Gas Pipe Line Corp.	421	30–36	Loops on Texas-New York main line.	Planned
Transcontinental Gas Pipe Line Corp.	57	—	Louisiana, Mississippi and Alabama.	Proposed
Transcontinental Gas Pipe Line Corp.	19	12	Vermilion Parish, Louisiana	Proposed
Trans-Canada Pipe Lines, Ltd.	2247	14–36	Alberta area to Toronto, Montreal	Planned
Trans-Northwest Gas Inc.	246	—	International Boundary to Washington and Idaho.	Proposed
Trans-Northwest Gas	275	—	Branch lines.	Proposed
Union Gas Company of Canada	180	—	Dawn Storage field to Hamilton.	Proposed
United Gas Fuel, and Central Kentucky Natural Gas	92	—	Gulf Interstate system, Boyd County, Kentucky to Putman County, W. Va.	Proposed
United Fuel Gas	50	20–24	Wood County to Hanham, West Virginia.	Proposed. Spring 1954
United Fuel Gas	32	24	Near Ripley, West Virginia to Lanham station, Putman County, West Va.	Proposed
United Fuel Gas	57	30	Lanham in Kanawha County, West Va., to Gulf Interstate line.	H. C. Price Co.
United Natural Gas Company	50	12	Elk County to Jefferson County, Pennsylvania.	Planned
Utah Natural Gas Company	63.7	18	Clear Creed to Orem, Utah.	R. H. Fulton
Utah Natural Gas Company	40	16	Orem to Salt Lake City, Utah.	Planned
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Va.	Proposed
Warren Petroleum	54	4–30	Lea County, New Mexico.	Planned
Western Pipe Lines	833	24	Southern Alberta across Canadian prairies, serving intermediate cities.	Planned
Wyoming Gas Products Corp.	—	—	Gas gathering system in Weston county, Wyo.	Planned
FOREIGN CRUDE LINES				
Arabian American Oil Company	18	22–20	Qatif to Ras Tanura No. 3.	Completion date 1-55.
Bombay Port Trust	50	8 to 24	Bombay, India, to serve Standard Vacuum Oil Co.	Merritt, Chapman and Scott Corp.
Creole Petroleum Corporation	21	34	Lagunillas to La Salina (State of Zulia, Venezuela)	Williams Brothers Overseas Company
Direction General de Yacimientos Petroliferos Fiscales	409		Plasa Huincul to Bahia Blanca, Argentina.	Under way
Iraq Petroleum Company	—	20	Line diversion from Kirkul-Haifa line to Lebanese coast terminal.	Planned
Petroleos Mexicanos	145	12	18 de Marzo field via Raynosa to Monterrey.	Considered
Petroleos Mexicanos	72	12	Poza Rica to Atzacapotzalco, Mexico.	Proposed
Petroleos Mexicanos	125	10	Jose Colomo to El Plan, Mexico.	Under way
Saskatoon Pipe Line, Limited	56	6	Milden to Saskatoon, Saskachewan, Canada.	Planned
Texas Petroleum Co.	60	4–6	Pta. Nio to La Dorada.	Under way
Yacimientos Petroliferos Fiscales Bolivianos	170	4	Bermejo to Tupiza, Bolivia.	Planned
FOREIGN PRODUCT LINES				
Anglo-Iranian Oil Company, Ltd.	18½	6&16	Little Aden to Aden.	Bechtel Corporation.
Anglo-Iranian Oil Company, Ltd.	15	12	Kwinana to Fremantle.	M. W. Kellogg Company. Completion date Feb., 1955.
Anglo-Iranian Oil Company, Ltd.	17	6	Kwinana to Fremantle.	M. W. Kellogg Company Completion date Feb., 1955.
Columbian Ministry of Petroleum	115	4	La Dorado to Cartago, Columbia.	Williams Brothers Engineers.
Columbian Ministry of Petroleum	93	8	Cantimplora to Dorado, Columbia.	Williams Brothers Constructors.
Empresa Nacional del Petroleo	80	6⅝	Concon to Santiago, Chile.	Planned
Governments of Southern Rhodesia and Portuguese E. Africa	200		Beria, Portuguese Mozamque to Umtalia, Southern Rhodesia.	Considered
North Atlantic Treaty Organization (NATO)	1920	4–10	To serve military bases in Western Europe.	Foster Wheeler
Petroleos Mexicanos	124	6	Lagos to Guadalajara, Mex.	Planned
Petroleos Mexicanos	54	6	Lagos to Aguascalientes, Mexico.	Planned
Petroleos Mexicanos	82	8	Salamanca to Lagos, Mex.	Planned
FOREIGN GAS LINES				
Azienda Generale Italiana Petroli	90	12	Cortemaggiore to Bologna, Italy.	SNAM crews
Azienda Generale Italiana Petroli	120	16	Cremona Porto Mar to Ghera, Italy.	Montubi, Contractor
Azienda Generale Italiana Petroli	40	12	Rapalta-Bergamo, Italy.	
Dirrecion General del Gas del Estado	310	8	Plasa Huincul to Neuquen, Argentina.	
Empresa Nacional del Petroleo	80	10	Concon to Santiago, Chile.	Planned
Northwest Natural Gas Company	950	24	Alberta fields to Vancouver, British Columbia, Seattle, Wash. and Portland, Ore.	Planned
Petroleos Mexicanos	205	16	Monterrey to Torreon, Mex.	Under way
Petroleos Mexicanos	440	20	Brasil to Tampico to Poza Rica, Mexico.	Planned
Sui Gas Transmission Company, Karachi, Pakistan	350	16	Sui gas field to Karachi, Pakistan.	Planned

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PIPE LINE PICTORIAL

Pictures, left column, top to bottom:

G. H. "Ozzie" Osborn, C-R-C Engineering Company, and G. V. Jones, Arkansas-Louisiana Gas Company.

E. D. Vines and Frank Moreland, Koppers Company.

R. J. Sarraf, Ray McWhorter, D. R. Barham, all of Rockwell, and J. O. Morrow and J. W. Reed, both of Saran.

Vernon E. Percell, W. G. Swanson, both of Gas Service Company; T. D. Williamson, Jr., T. D. Williamson, Inc.; and Harold W. Rose, Gas Service Company.

R. H. Maloy, Insul-Mastic; and J. N. Wickersham and Jack Grady, both of Corrosion Control, Kansas City

Floyd Zongker, T. D. Williamson, Inc., and John D. Johnston, Jr., and O. D. Meek, both of Alabama-Tennessee Natural Gas Company.

Right Column, top to bottom:

Walter L. Jones, Natasco, and L. G. Sharpe, Humble Pipe Line.

J. E. Parrott, Jr., and C. E. Morgan, both of Phillip Carey Manufacturing Company, and Jim Neal, Fiberglas, Dallas.

Kenneth Burkhead, Kansas City, and Robert J. Chapple, Rust-Oleum.

Doyle Johnson, Midwestern Constructors; Frankie Forte, Fiberglas; Phil Davidson, C-R-C Engineering; Austin Boyd and Bill Wilhite, Midwestern Constructors.

E. J. Brecht, Cities Service Pipe Line, and Don L. Korn, Natasco.

J. R. Hagerman, Barrett; F. J. O'Leary, Barrett, and William L. Scull, Colorado Interstate Gas Company.

NACE AT KANSAS CITY

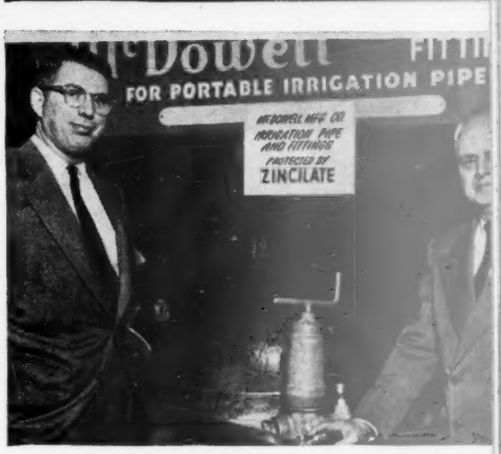
Pictures, left column, top to bottom:

Frankie Forte, Fiberglas.

Walter F. Rogers, left, turns over NACE presidency to Aaron Wachter.

Tom Billings, right, Thornhill-Craver, Houston, and R. A. Brannon, Humble Pipe Line.

Mel Maddox, Perrault Equipment Company, and J.C. Stirling, Service Pipe Line Company.



R. A. Brannon, Humble Pipe Line, Norman Hamner, NACE, at the NACE registration and headquarters booth.

Right Column, top to bottom:

Committee chairmen who helped make NACE Kansas City meet a success, left to right, are C. C. Keane, Great Lakes Pipe Line; Harry K. Phipps, Socony-Vacuum; George A. Venneberg, Great Lakes Pipe Line, and O. E. (Ted) Murrey, Midwestern Engine and Equipment Company.

William H. Ryan, Industrial Metal Protectives, Inc., and H. L. Fuller, Industrial Coatings Engineering Company.

V. J. Scarola and Robert Zito, Tapecoat.

Ray Trapp and Tom Mitchell, Midwestern Engine and Equipment Company.

Stanley Wilson and Arthur Donnelly, Bart Electro-clad.

XUM

J. N. Johnston, W. D. Siddall, and Miss Ila Vermillion, Federal Telephone and Radio Company.

Walt Sutter, General Electric. Sutter is author of a series of articles on "Microwave System Design," beginning in this issue of *The Petroleum Engineer*.

Engineers Ted C. Schroeder and Paul Eckhardt, Union Switch and Signal, discussing new Centralized Transport Control system.

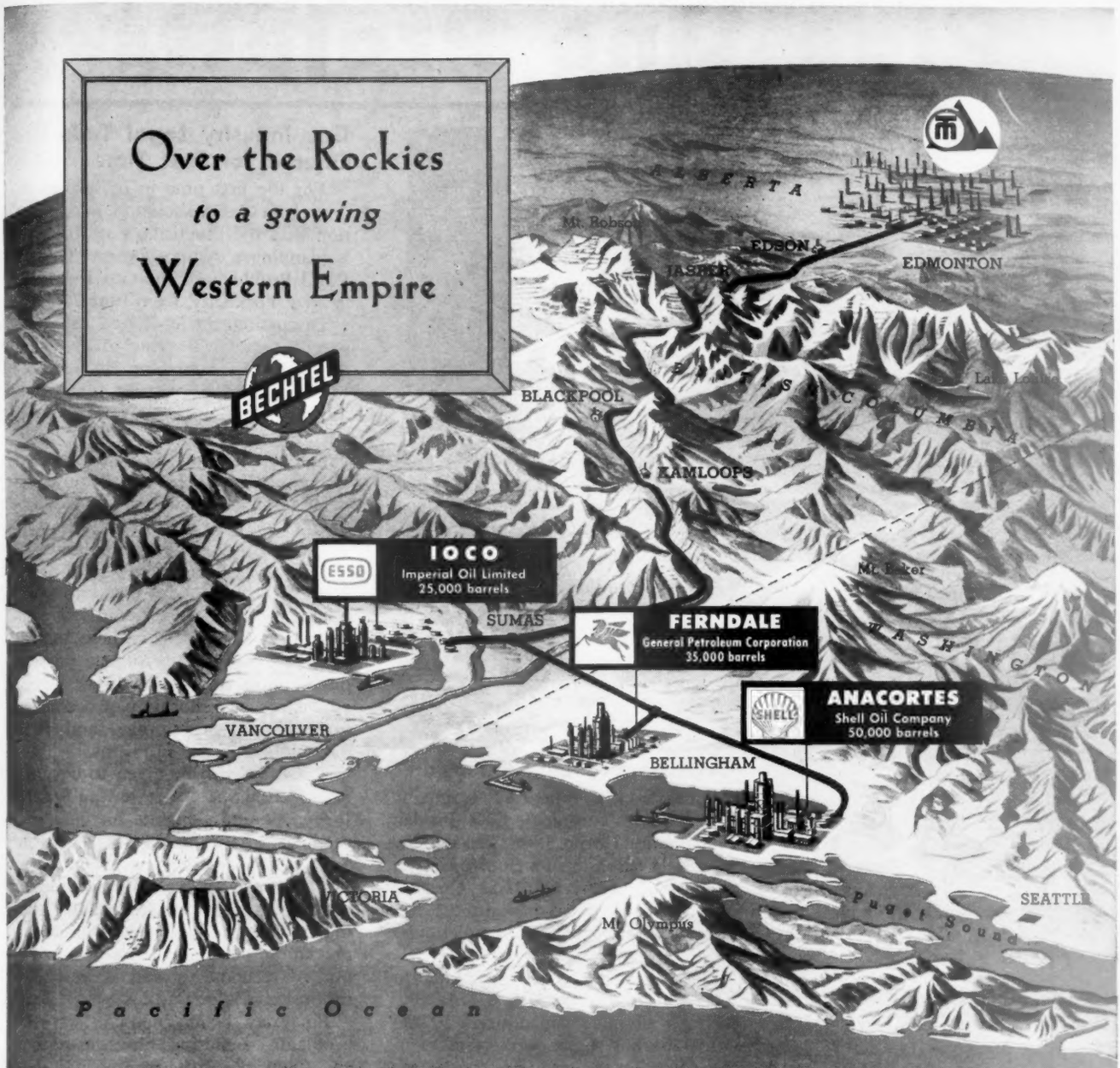
E. J. Agnew, A. S. Robertson, and C. E. Lane, Union Switch and Signal.

Pipeliners L. J. Mecum and W. M. Wiley, Texas Pipe Line Company, take time out for coffee at PIEA-PESA meeting.

PIEA-PESA Meeting at Dallas

C. A. Saville and Tom Brown of Nelson Manufacturing Company.

E. H. Wilder, Sun Oil Company, and H. F. Timmins, Kellogg Switchboard and Supply Company.



A bright new era of industrial development is starting in the Pacific Northwest, now that the region has an assured supply of oil. Completion of the 718-mile Trans Mountain Oil Pipe Line is being implemented in British Columbia and Washington by the extensive construction of petroleum processing facilities.

Among the refineries which now or upon completion will have available Alberta crude oil from Trans Mountain or its U. S. lateral are:

- Imperial Oil Limited's new 25,000 barrels-per-day refinery at Ioco, British Columbia.
- General Petroleum Corporation, Socony-Vacuum's western affiliate, 35,000 barrels-per-day refinery at Ferndale.
- Shell Oil Company's 50,000 barrels-per-day refinery at Anacortes.

Bechtel has a key role in these programs—as designer, engineer and constructor of the refineries; and as owner's agent, engineer and manager of construction of the Trans Mountain Oil Pipe Line.

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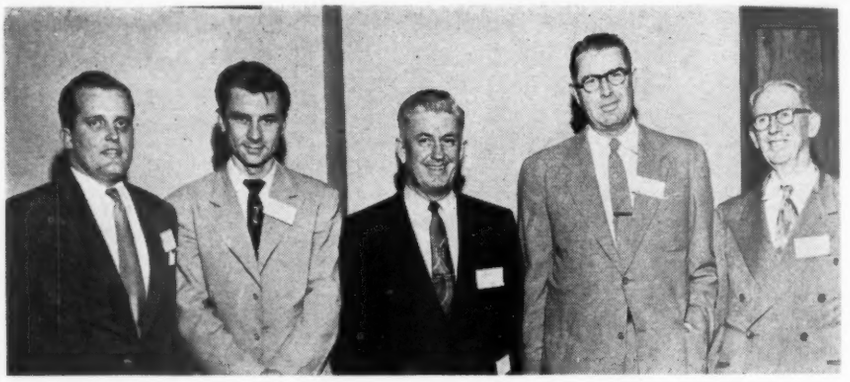
Pipe Line Projects



Speakers on the program at first general meeting of the American Society of Civil Engineers "Committee on Pipe Lines" at Midland, Texas, were, John H. Mitchell, Lockwood, Kessler and Bartlett, New York; Earl K. Monteith, Studdert Engineering, Midland; Eldon V. Hunt, Ebasco Services, New York; Walter H. Davidson, Transcontinental Gas Pipe Line, Houston, and C. M. Davis, chairman of the committee.

Jungle Pipeline Planned

Assam Oil Company's new well, in the Nahorkatiya area of the Brahmaputra Valley in north-east India, is now accounting for 20,000 bbl per day. This output is to be refined at Digboi some 20 miles away. Oil was found at Nahorkatiya at a depth of 11,715 ft, the deepest ever drilled in India. Assam Oil Company is now pressing on with the drilling of a second well in the area, and a site has been chosen for a third well, where drilling is slated to start within a few months. A road is being cut through the jungle to connect the new field with Digboi refinery, and an 8-in. pipeline is being laid.

Montana Products Pipe Line Slated for Construction

Oil Basin Pipeline Company has announced plans for a new 230-mile, 8-in. products line from Laurel, Montana, to Glendive, Montana. The $5,350,000 line would pass through Billings and have an initial capacity of 12,000 bbl per day. Addition of another pumping station would increase capacity to 20,000 bbl daily.

Construction of the line is expected to get underway as soon as weather permits and operations are expected to begin by autumn. Products will be supplied by Carter Oil Company's 25,000-bbl refinery at Billings and the 15,000-bbl Farmers Union Central Exchange refinery at Laurel.

Plains Pipe Line Sale To Coal Firm Approved

Wyoming's Public Service Commission has put its stamp of approval on the sale of the Plains Pipe Line system between Lance Creek and Newcastle, to Franklin County Coal Company.

Price of the line is estimated at $2,025,000. Principal owners are the Clint Murchison interests of Dallas and an independent group of shareholders represented by Keith Thompson, Cheyenne attorney.

Burden Awarded Contract on Cities Service Line Extension

Cities Service Pipe Line Company has awarded a contract to O. R. Burden Construction Corporation, Tulsa, to lay a 60-mile extension to Houston of its Sour Lake, Texas, to Lake Charles, Louisiana, oil line. Work on the 12-in. extension has begun and completion is scheduled for mid-June.

Initial capacity of the Sour Lake to Houston line will be 48,000 bbl daily, with an ultimate capacity of 70,000 bbl. Work has begun on the tank farm at Fauna, Texas, near Houston, where six 120,000-bbl floating-roof tanks are being erected. Coating contract has been awarded to Secco Pipe Coating.

Gas Industry Legal Talks Offered for First Time

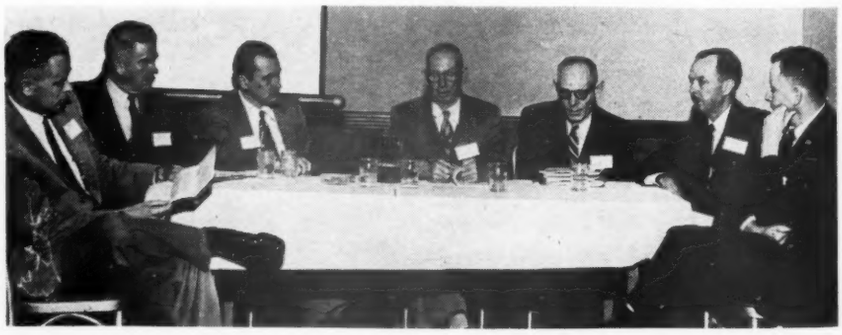
For the first time in its history the American Gas Association, in cooperation with the Practising Law Institute, is planning a symposium on "Current Legal Problems of the Gas Industry," in New York City, from June 7-11.

Discussion by legal and other experts, of practical value to gas utility and pipe line company lawyers and executives, will comprise typical gas industry legal problems from wellhead to burner tip.

Subjects during the comprehensive all-week sessions include natural gas field supply, negotiations and analyses of gas purchase contracts, state commission prorations and minimum price orders, and effects of the Phillips decision. Another day of discussions will be devoted to transportation and common carrier problems. These include pipe line company certificate matters, intervention and compulsory service as well as gas allocation proceedings, underground gas storage, and jurisdictional certificate problems.

Two days will be given to covering rate-making matters, reviewing Federal Power Commission rate increase proceedings, applicable rate-making principles, FPC settlement proceedings, fair field costs and values, plus proof of fair rate of return and fair value. Other topics include use of economic depreciation, determination and distribution of refunds, as well as cost allocations.

Final day sessions will concern sales problems, centering on construction and filing of tariffs, federal and state jurisdiction and legislation, customer problems under gas tariffs, and rate problems during conversion.



Members of the Committee on Pipe Lines of the ASCE at the group's conference following the first meeting of the committee at Midland, Texas, in April. Attending are: Steve D. Bechtel, Jr., Don P. Reynolds, Eldon V. Hunt, Charles M. Davis, Joseph B. Spangler, Stanton E. Huey, and Arthur E. Poole. Hunt was elected chairman of the committee for 1954. Davis is out-going chairman, and Spangler is secretary. Next meeting will be in New York City at the annual ASCE conference in October.

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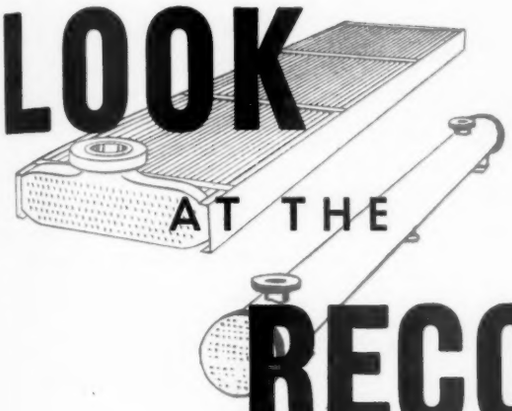

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Vast Canadian Gathering System Given Approval

A preliminary permit for construction of a crude oil gathering system and transmission line connecting Pembina area of west-central Alberta to terminals of Trans Mountain and Interprovincial Oil Pipe Lines at Edmonton has been granted Pembina Pipe Line Company, Ltd.

Pembina oil field has been called "the most significant oil discovery of the past year." Detailed surveys and final specifications will be submitted to the Department by June 1, according to J. A. Scott, an official of the Pembina Pipe Line Construction to begin as soon as possible afterwards.

The gathering system — one of the largest in the world — will tie-in at least nine townships during initial construction phases. Gathering lines will vary in size from 3 to 12-in., and will total an estimated 325 miles. Gathering phase of construction will cost an estimated $6,000,000. Main pumping station is tentatively about 12 miles due north of Buck Lake. Station initially will have at least two pumping units with approximately 100,000 bbl of oil storage capacity.

Military Plans Spanish Product Line System

A products pipe line, extending 300 to 500 miles, is currently under design by the Navy Department for use in serving a naval base and several air bases to be established in Spain under a recent agreement between the U. S. and Spanish governments.

Route of the pipe lines remains to be selected, as the naval base, air fields, and pipe line are being designed as a unit.

Contractors for the engineering and planning have already been selected by the Navy. Brown and Root, Inc., Raymond Concrete Pile Company, and Walsh Construction Company will handle overall project.

Southern Natural Expansion Program Plans '54 Completion

Southern Natural Gas Company plans to complete its expansion program begun in 1952 with the construction of about 250 miles of 16 and 18-in. lines and addition of 4400-hp in compressor facilities. Cost of the project is estimated at about $12,500,000.

The construction planned for 1954 would include loop lines on the company's South line and lines connecting the North and South lines near its Gwinville, Mississippi, station. Numerous new cities would be added to Southern Natural's customer list through construction of the facilities.

Great Lakes Planning To Increase System Capacity

Increased capacity for Great Lakes Pipe Line Company delivery terminals at Alexandria, Minnesota, and at Fargo and Grand Forks, North Dakota will be provided by new lines to be constructed this summer.

A 12-in. line will be laid laterally from existing lines near Minneapolis westward to Willmar, Minnesota, where it will parallel the present 8-inch line to Alexander. From there an 8-in. extension will be built along the route of an older 6-in. line to Fargo. The new lines will be completed in August.

A 12-in. line will be laid this summer between Kansas City and Des Moines to supplement the 12-in. and two 8-in. lines. Capacity of the 12-in. line between Des Moines and Minneapolis will be increased by powering it with pumping stations at 50-mile intervals instead of the present 100 mile spacing. This will be done by installing pumping units on the 12-in. line at existing mid-point stations.

Colorado-Interstate Given Approval on 50-Mile Line

The FPC has authorized the construction of pipe line facilities designed to enable Colorado Interstate Gas Company to deliver additional quantities of natural gas to Natural Gas Pipeline Company of America.

Colorado Interstate will construct, at an estimated cost of $3,999,703, about 50 miles of 20-in. pipe line from the Morton County, Kansas, gas field to a point of connection with Natural near Hooker, Oklahoma; a dehydration plant in Morton County, and a delivery meter station.

Natural will build facilities near Hooker to enable it to receive the additional natural gas from Colorado Interstate. Estimated cost of Natural's construction is $665,000.

Kansas-Nebraska Gas Plans 223 Miles New Pipe Lines

Kansas-Nebraska Natural Gas Company, Inc., Phillipsburg, Kansas, has applied to the FPC for authorization to construct a total of about 223 miles of pipe line and 2700-hp in compressor capacity to provide additional capacity to meet growing natural gas requirements on its system in central and northeastern Nebraska.

Total estimated cost of the proposed construction program is $4,096,890. The proposed 223 miles of new pipe would range in diameter from 6 to 12-in. Of the proposed additional compressor capacity, 1500-hp would be installed at a new station and the remaining 1200-hp at an existing station.

Sunflower Pipe Line Plans Kansas Products Line

A certificate of necessity covering a $3,500,000 products pipe line has been given Sunflower Pipe Line Company, Tulsa, Oklahoma, by the PAD. The 265-mile line, with pipe sizes of 3 to 6-in., would have a capacity of 15,000 bbl per day, and would run from natural gasoline plants in Kearny, Grant, and Haskell counties to Wichita, Kansas.

New Pipe Line Contracting Group Organized in East

East Coast Pipe Line Construction Company, with headquarters at 576 Newark Avenue, Jersey City, New Jersey, has been organized to do general pipe line construction work. Officers of the new firm include A. J. Ferrara, president, and J. P. Romine, vice president.

Trans Mountain Awards Contract on Spur Connection

Trans Mountain Oil Pipe Line Company has awarded a contract for construction during 1954 of the "Ferndale Spur" consisting of approximately 15 miles of 20-in. and 11 miles of 16-in. pipe line to Engineers Limited Pipeline Company, San Francisco, California, and Seattle, Washington. The $2,000,000 line runs generally southwestward from a point on the British Columbia-Washington state border near Sumas to the new refinery of General Petroleum, Ltd., near Ferndale, Washington.

Expansion planned for 1955 will include extension of the 20-in. line south from Laurel a distance of 27 miles to near Mt. Vernon, Washington, where a 10-mile, 16-in. line will carry crude to a new Shell refinery at March's Point.

Fulton Awarded Great Lakes Products Extension Contract

Contracts for construction of Great Lakes Pipe Line Company's 8-in. line from its Nebraska City, Nebraska, pumping station to a site at Doniphan, Nebraska, midway between Hastings and Grand Island, where a delivery terminal will be built.

R. H. Fulton & Company of Lubbock, Texas, was successful bidder on the two jobs of the 132-mile section. Tulsa Coating Company will coat line pipe at Lushton and Jamaica, Nebraska, locations where it is being stockpiled.

Officials of the petroleum products carrier said bids soon will be asked on construction of Doniphan terminal facilities and an electric powered pumping station near Lincoln.

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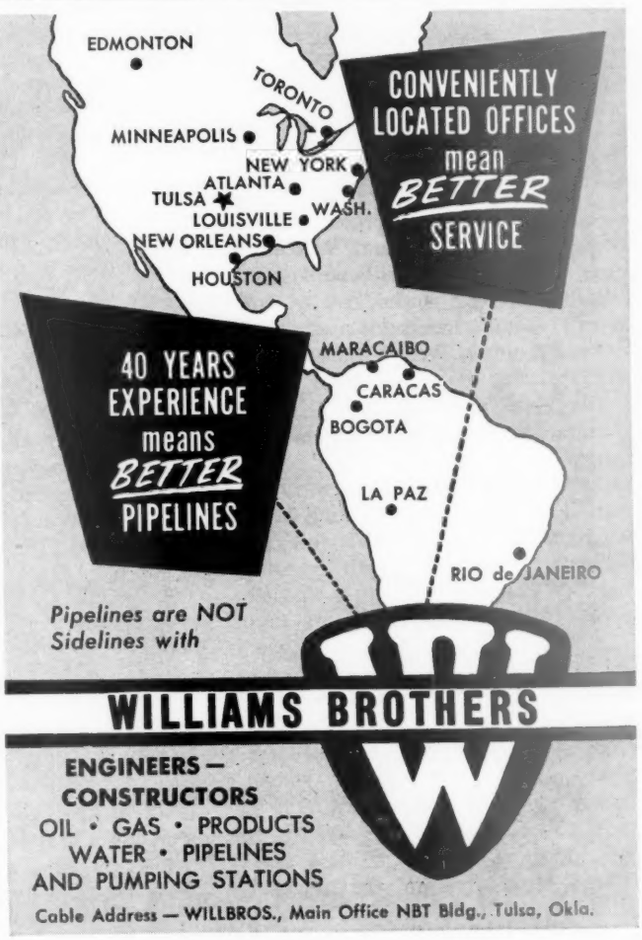

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$40,000,000 in Projects, Lines Slated by Columbia Companies

FPC has issued certificates to six subsidiaries of The Columbia Gas System, Inc., for the construction of new pipe line facilities, having a total estimated cost of more than $40,000,000, which are generally designed to increase the Columbia System's capacity to receive, transport, store and deliver natural gas.

The certificates were issued to Manufacturers Light and Heat Company, Central Kentucky Natural Gas Company, Home Gas Company, Atlantic Seaboard Corporation, United Fuel Gas Company, and Ohio Fuel Gas Company.

Seaboard's project, which is estimated to cost about $14,619,300, includes approximately 116 miles of pipe line paralleling sections of the company's existing line between Cobb, West Virginia, and Rockville, Maryland, including about 10½ miles of looping line near Baltimore, Maryland. Seaboard also will construct a total of 4400 hp in new and existing compressor facilities in West Virginia and Maryland.

The certificate issued jointly to United Fuel and Central Kentucky covers the construction of facilities required to receive natural gas to be available to the Columbia System companies beginning with the 1954-55 winter from the system of Gulf Interstate Gas Company, which is now constructing an 850-mile line extending from Louisiana to Kentucky.

The United Fuel-Central Kentucky project will cost an estimated $9,114,-222. It includes about 59 miles of pipe line and a 6000-hp compressor station, located in Kentucky and West Virginia. In another certificate issued, United Fuel was authorized to construct a 4400-hp compressor station in Jackson County, West Virginia, at an estimated cost of $2,240,000.

Two certificates also were issued to Manufacturers. One authorizes the construction of facilities, estimated to cost $3,747,446, to activate a new underground storage field in Wetzel and Marshall Counties, West Virginia, and to connect the new pool with Manufacturers' existing facilities. This project includes about 33.7 miles of main transmission line, 21½ miles of main storage field lines, 17.1 miles of field well lines, and a 1760-hp compressor station.

The other certificate authorizes eight separate jobs by Manufacturers, with a total estimated construction cost of $5,968,300. The facilities are to be constructed (1) in the "tri-state area" around Pittsburgh and the northeast panhandle of West Virginia, and constitute replacements of existing facilities, and (2) in and around eastern Pennsylvania, near the Maryland state line, to reinforce Manufacturers system in that area.

Ohio Fuel Gas Company will construct a total of about 63 miles of pipe line, largely to replace existing facilities, to provide additional capacity to certain of its Ohio markets. Estimated cost is $2,668,000.

Home Gas Company will build a total of approximately 50 miles of line in sections from Maine to Tioga, New York, and Deposit to Port Dickinson, New York. This project, estimated to cost $2,160,500, will complete the company's replacement of its multiple 6-in. system of lines from Quackenbush Hill to Port Jervis, New York.

Crude Line Activity In West Texas; 3 Lines Planned

Atlantic Pipe Line Company has announced plans for construction of 40 miles of new 8-in. line to be built between the firm's Andrews station and its tankfarm near Midland, Texas. The line will have a capacity of 25,000 bbl per day and will parallel an 8-in. line presently in use. Work is to begin immediately and completion is planned by mid-June.

Atlantic also plans to lay 13 miles of 6-in. line in Gaines county between its Russell and Wood stations.

Service Pipe Line Company is planning an 8-in. line to the Midland Farms deep field to pick up sweet crude. The 27-mile line would extend to the company's Fullerton station.

Shell Pipe Line Corporation has taken over operation of a 43-mile line formerly owned by Sid. W. Richardson, Inc., Fort Worth. The line, formerly under lease to Atlantic Pipe Line, connects the Slaughter field in Hockley county.

Minnesota Company Formed, Plans New Crude Route

Formation of the Minnesota Pipe Line Company to build and operate a new crude line to deliver crude from the Interprovincial-Lakehead system to a proposed $25,500,000 refinery at St. Paul, has been announced by Woodley Petroleum Company and Southern Production Company, principal stockholders in Great Northern Oil Company that will operate the proposed refinery.

Take-off point for the line would be at either Clearbrook, Minnesota, or Superior, Wisconsin.

Plans have also been revealed on a possible 150-mile crude line from the Fosterton field area in southwestern Saskatchewan to Regina, connecting with the Interprovincial-Lakehead system, that would supply 20,000 bbl daily for the Great Northern refinery when it is in operation.

RFC Against West Coast Line

The Reconstruction Finance Corporation has recommended against government aid in financing a crude oil line from West Texas to California as proposed by West Coast Pipeline Company, Dallas, Texas. Negative recommendation was made by PAD to the Office of Defense Mobilization which, in turn, passed it to the RFC.

Action was taken on an application by L. M. Glasco, Dallas, West Coast president, who asked RFC for a certificate of essentiality under the Defense Production Act. West Coast asked for government guarantee for mortgage investors of the line in the event it operated at low capacity resulting in loss. A guarantee of $80,000,000 towards the investment in facilities was made by Glasco.

RFC officials agreed that the Texas-California line would contribute to national security, but that a line from the Southwest to the East Coast "far outweighs the need for such transportation to the West Coast." An East Coast line should be given "first priority," RFC said.

Standard Terminal Planned

Standard Oil Company (Indiana) has announced plans to build a distribution terminal near Latayette, Indiana, to serve northwest-central Indiana and part of eastern Illinois. The terminal, about two miles south of Brookston, Ind., in southern White county, will be served by Standard Oil's products pipe line running from the company's refinery at Whiting, Ind., 84 miles north, to Indianapolis, Ind., 66 miles south.

Construction is slated to start about mid-May, with completion scheduled by November 1. Standard said, however, the terminal probably would start operating about the first of October, before final grading and painting has been completed.

North Dakota Line Planned

Montana-Dakota Utilities Company, Minneapolis, Minnesota, has applied to the FPC for authority to construct 56 miles of pipe line in Hettinger and Stark Counties, North Dakota, to supply natural gas to Regent, Mott, New England and Lefor, North Dakota. This area is not now served with natural gas.

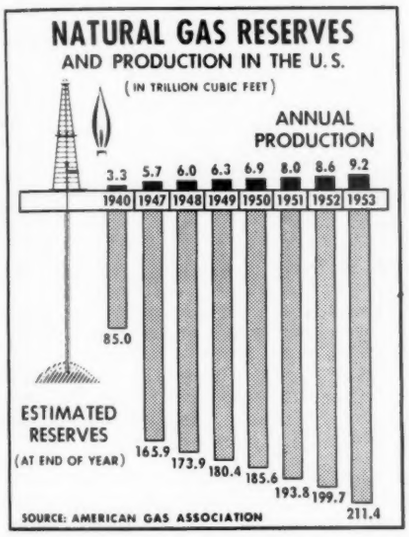
In addition to the 56 miles of gas transmission line, the company also proposes to construct distribution systems in the four towns. Total estimated cost of the project is $728,854.

Work Underway on Shell's Louisiana Products Line

Houston Contracting Company has begun work on Shell Pipe Line Company's 65-mile, products pipe line from Shell's Norco, Louisiana refinery, west of New Orleans, to a point near Baton Rouge.

The 12-in. line will cross varying terrain, including a two-mile stretch across the Bonnet Carre Spillway and nearly 12 miles of swampland. Completion date is set for mid-summer.

A pump station will be built adjacent to the refinery, giving the line an initial capacity of 50,000 bbl per day of kerosine, distillate fuel oil and two grades of gasoline. At Baton Rouge, the products will enter the Plantation Pipe Line for further shipment to Southeastern states. Capacity of the new line can be increased to 80,000 bbl per day by addition of another pump station.


NATURAL GAS RESERVES
AND PRODUCTION IN THE U.S.
(IN TRILLION CUBIC FEET)
ANNUAL PRODUCTION
3.3 5.7 6.0 6.3 6.9 8.0 8.6 9.2
1940 1947 1948 1949 1950 1951 1952 1953
85.0
ESTIMATED RESERVES (AT END OF YEAR)
165.9 173.9 180.4 185.6 193.8 199.7 211.4
SOURCE: AMERICAN GAS ASSOCIATION

Natural gas reserves continued to expand in 1953. At end of year 11.7 trillion cubic feet had been added to proved recoverable reserves.

Appalachian Short Course Planned for August

The 14th annual Appalachian Gas Measurement Short Course will be held at West Virginia University, Morgantown, West Virginia, August 23-25. Only course of its type given east of the Mississippi, the session is attended annually by measurement and control engineers and other technical personnel representing the petroleum, gas and chemical industries. Subjects to be covered will include fundamentals of gas measurement and special sessions on domestic meters, large capacity meters, orifice meters, auxiliary measurement instruments, automatic control instruments, planning and design of installations, and pressure regulators, motor valves, and related equipment. Close to 100 industrial experts will discuss special phases of these subjects.

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WITH THE PIPE LINE CONTRACTORS

Oklahoma Pipe Line Constructors, 6612 Harry Hines Boulevard, Dallas, Texas, has contract for 60 miles of 12-in. takeup, recondition and relay for Montreal Pipe Line Company between Sutton and Montreal, Quebec. Guy Craft is superintendent and Jack Brown office manager. Job expected to get underway by June 1.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma, has contract for 189.2 miles of 30-in. for Northern Natural Gas Company, in 11 loops. One spread is working out of Perryton, Texas, on 94.3 miles in 5 loops, one in Texas, one in Oklahoma, and three in Kansas, with M. T. Wilhite, superintendent; John Work, spreadman, and N. O. Boies, office manager. Other spread is working on 94.9 miles in six loops, one in Kansas, one in Nebraska, three in Iowa, and one in Minnesota. Spreadman is Benver L. Franklin, office manager is Bernie Segal, and Wilhite is superintendent.

Company also has contract to dismantle pumping station at Alemeda, Texas, move building and equipment and construct new station at Adena, Colorado, for Pawnee Pipe Line Company. Eldon Rolfe is superintendent of this job.

Company also has contract to construct pump station at Fergus Falls, Minnesota, for Standard Oil Company. Charles Malone is superintendent and Frank Conway is office manager.

Anderson Brothers Corporation, P. O. Box 2591, Houston, Texas, has contract for 51 miles of 26-in. loop for Lakehead Pipe Line. Work will begin when weather and ground condition permits. R. L. Leonard is superintendent.

Anderson Brothers of Colombia, 704 Prudential Building, Houston, Texas, has 60 miles of 8-in. products line for Empresa Colombiana de Petroleos. Rusty Killingsworth is superintendent on the South American job.

Company also has 30,000 ft of 8 and 16-in. line in Lake Mararcaibo, Venezuela, for Shell Oil Company. Earl Saulsman is superintendent.

Anderson International Contractors, Edmonton, Alberta, has contract for 201 miles of 24-in. loop for Interprovincial Pipe Line Company in two sections, including one section of 101 miles between east bank of South Saskatchewan River and Regina, and another 100 miles between Regina, Saskatchewan, and Gretna, Manitoba. Whitey Gould is superintendent of spread work on 101 mile section, out of Regina field office, and Buster Watson is superintendent of other spread with headquarters in Gretna. R. W. Dick Jernigan will be in charge of over-all project. Pipe to begin on June 1.

Associated Pipe Line Contractors, Inc., Houston, Texas, is working on 175 miles of 10-in. line from Bozeman, Montana, to Clinton, Montana, for Yellowstone Pipe Line Company. Jim Ed Andrews is superintendent and Buck Johnson office manager at the Bozeman field office.

Collins Construction Company, Victoria, Texas, has contracted from Merritt-Chapman and Scott of India for construction of 84,000 ft of submarine line in the harbor at Bombay, India.

Dunn Brothers, 801 Mercantile Building, Dallas, Texas, has reported the following hauling, stringing and unloading jobs:

335 miles of 30-in. for Gulf Interstate Gas Company between Kinkade, Tennessee, and Kenova, West Virginia. Prime contractor is H. C. Price Company.

140 miles of 30-in. for Tennessee Gas Transmission Company between Savannah, Tennessee, and the Tennessee-Kentucky state line.

62 miles of 30-in. for Tennessee Gas Transmission Company between Lisbon and Cambridge, Ohio.

Various sizes for El Paso Natural Gas Company in the Farmington, New Mexico, area. El Paso is doing own construction.

208 miles of 20-in. for Magnolia Pipe Line Company, Corsicana to Beaumont, Texas. Prime contractor is H. B. Zachry Company.

49 miles of 12-in. for El Paso Natural Gas Company, Farmington, New Mexico, to Rankin, Texas.

Eastern Pipe Line Contractors, 1801 Mercantile Bank Building, Dallas, Texas, has completed one of two sections of the Yellowstone Pipe Line System between Billings, Montana, and Spokane, Washington. Eastern has 40 miles left of 158 miles of the 10-in. line. Spread working east out of Murray, Idaho. A. L. "Bull" Stewart is superintendent and J. W. Arthur, office manager.

Engineering-Construction Company, 402 North Cheyenne, Tulsa 6, Oklahoma, is working on 24 miles of 4-in. lateral for City of Dallas, Georgia. Jimmy Williams is superintendent and V. L. Bethel, office manager.

Company also has contract for 150 miles of 8 and 10-in. between Phoenix City and Dotham, Alabama, for Southeast Alabama gas district. Job will start later in year.

Houston Contracting Company, Ltd., 2707 Ferndale Place, Houston, Texas, has the following construction work:

Approximately 500 miles of 30-in. natural gas line for Gulf Interstate Gas Company from Rayne, Louisiana, to Kinkade, Tennessee. 370 miles have been completed and the remaining 130 miles will be handled as follows:

From New Albany, Mississippi, going north, E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, office manager; headquarters, New Albany, Mississippi. Pipe laying under way.

From Kinkade, Tennessee, going south, W. H. Hayes is superintendent; M. L. Thompson, assistant superintendent; J. B. Stoddard, office manager; headquarters Hohenwald, Tennessee. Work to start as soon as weather and ground conditions permit. Pipe laying under way.

Approximately 65 miles of 12-in. products line for Shell Pipe Line Corporation from Baton Rouge, Louisiana, to Norco refinery near New Orleans. H. J. Muckley is superintendent at the Baton Rouge field office.

Mannix, Ltd., Calgary, Alberta, is working on 129 miles of 24-in. loop for Interprovincial Pipe Line between Edmonton and Alberta-Saskatchewan border.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, has contract for 133 miles of 26-in. loop line for Lakehead Pipe Line Company in two sections, one 75 miles and the other 58 miles.

A. A. Carrigan is superintendent at the Clearbrook, Minnesota, field office, and Jim Magill is superintendent of other spread with field office at Cloquet, Minnesota.

Company also has 33 miles of 10-in. for Pawnee Pipe Line Company between Merino and Ft. Morgan, Colorado, and 20 miles of 6 and 8-in. gathering lines for Pawnee. Oscar Phillips is superintendent and Jerry Short office manager.

Fulton Banister Construction Company, 409 Northern Hardware Building, Edmonton, Alberta, is working on 124 miles of 24-in. loop for Interprovincial Pipe Line between Alberta-Saskatchewan border and west bank of South Saskatchewan River. Jack Flavin is engineer in charge at the Rosetown, Saskatchewan, field office.

Williams Pressure Service Company, 422 Commercial National Bank Building, Shreveport, Louisiana, hydrostatic pipe line testing company, is working on testing of additional gathering lines being added to Wilcox Trend Gathering System, Inc. T. V. McLeod is superintendent at Goliad, Texas. Company's other units are in yard at Shreveport for general overhaul.

H. B. Zachry Company, Transit-Tower, San Antonio, Texas, has contract for 208 miles of 20-in. for Magnolia Pipe Line Company between Corsicana and Beaumont, Texas. Work scheduled to get underway soon. About 112 miles of pipe to be used is being coated by C-R-C Engineering Company, Houston, and Mayes Brothers, Inc., Houston.

Vaughn and Taylor Construction Company, Inc., 2103 North Grant, Odessa, Texas, has contract for 100 miles of 2 to 10-in. gas gathering line in Stonewall County, Texas, for Stonewall Gas Products Company.

Z. J. Graham, Box 1203, Amarillo, Texas, has 9 miles of 16-in. near Amarillo for Pioneer Natural Gas Company. R. W. Miller is superintendent.

G. G. Griffis Construction Company, 4450 East Admiral Place, Tulsa, Oklahoma, is working on 56 miles of 8-in. crude line for Kaw Pipe Line near Norton, Kansas.

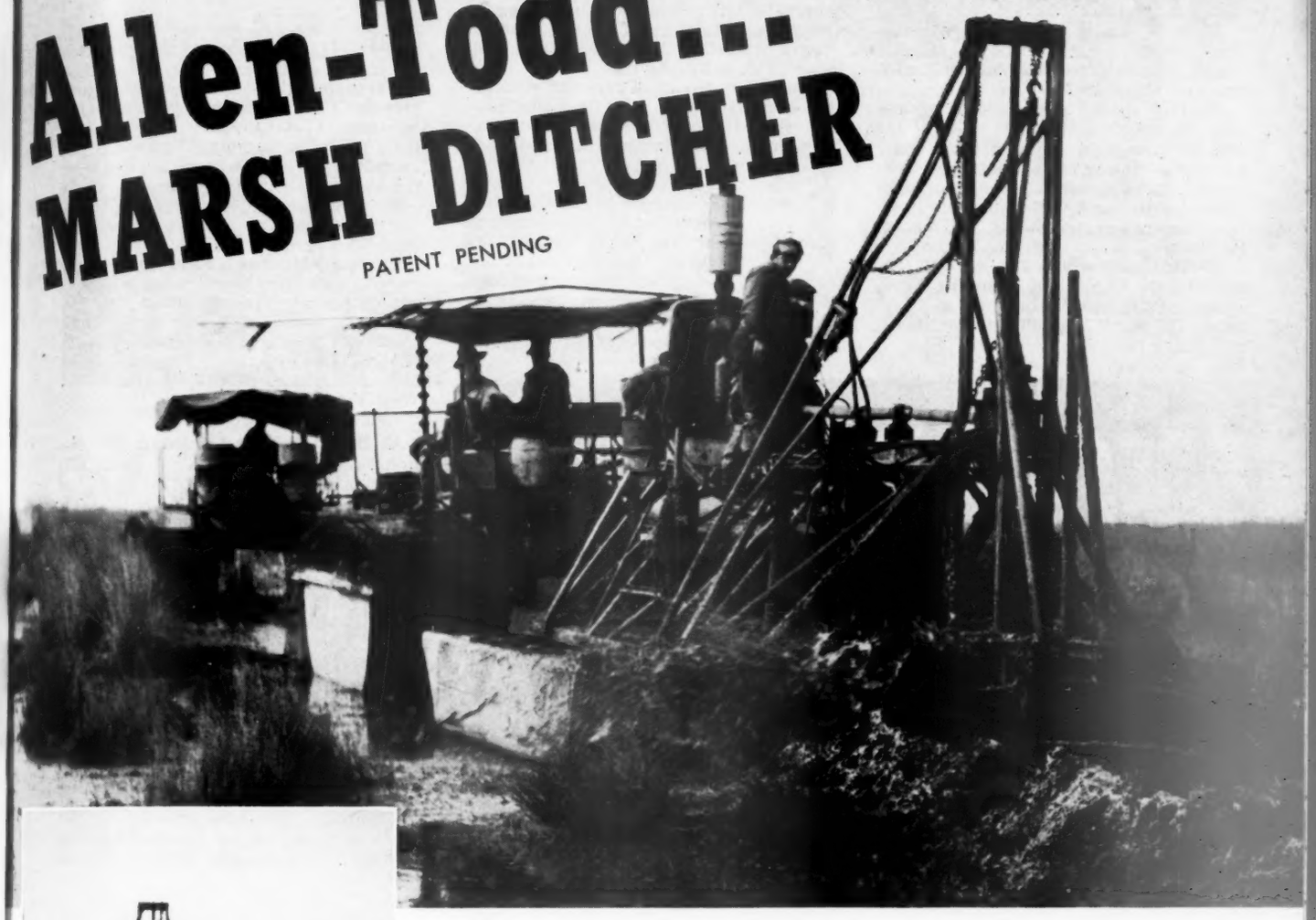
Foster Wheeler Corporation, 165 Broadway, New York 6, New York, has contract with North Atlantic Treaty Organization for management of 1920 miles of product line to be laid in Western Europe.

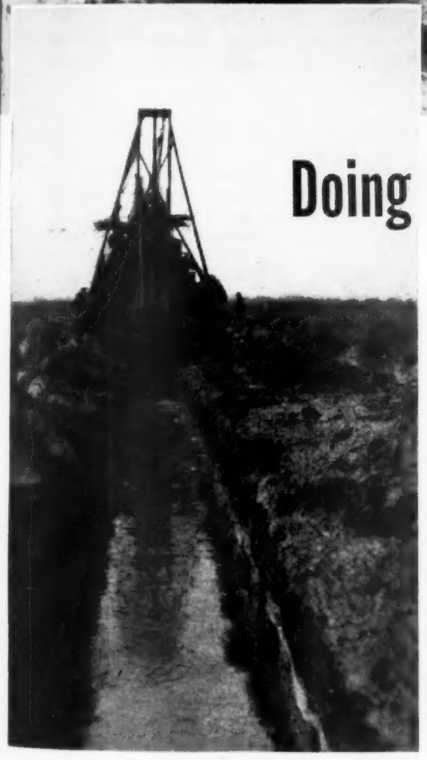
Engineers Limited Pipeline Company, 225 Bush Street, San Francisco, California has 109 miles of 34-in. line for Pacific Gas and Electric in two loops, one 79 mile section between Newberry and Danby, California, and a 30-mile section from San Martin to Tres Pinos, California.

Company also has 81 miles of 10-in. line for Yellowstone Pipe Line Company between Murray, Idaho, and Spokane, Washington. C. P. Hamilton is superintendent and Virgil Darby, office manager.

Allen-Todd... MARSH DITCHER

PATENT PENDING





Doing the impossible... through the impassible

When we undertook the construction of two pipe lines, laying sections through swampland and marsh inaccessible to conventional ditchers, draglines and other usual pipeline equipment, we were confronted with one of those "impossible" problems. A solution was quickly reached. It was this Allen-Todd Marsh ditching equipment, designed and built by us at a cost of $50,000.00.

Without trouble or difficulty, it ditched its way across the "impassable" swamp and marsh encountered on these two jobs: 43.6 miles of 12" line from Bay Marchand Station to Ostrica Terminal, Louisiana, for Gulf Refining Company, and 100 miles of 16", 12" and 6" lateral lines in South Louisiana for Gulf Interstate Gas Company.

It pays to associate with . . .

ASSOCIATED

PIPE LINE CONTRACTORS, INC.

Earl Allen, *President* • **J. W. Sharman,** *Vice President* • **John Gay,** *General Manager*

P. O. Box 13216 **LInden 7561**

HOUSTON 19, TEXAS

XUM

Contractors

Parkhill Truck Company, P. O. Box 1856, Tulsa, Oklahoma, reports the following work:

Hauling 30-in. pipe for Gulf Interstate Gas Company from Houston and Orange, Texas, to storage points in eastern Louisiana and Mississippi.

Hauling, storing where necessary, and stringing approximately 303 miles of 12-in. pipe from White River to Allen, Oklahoma, for Sunray Oil Corporation. Contractor, River Construction Corporation. Also approximately 97 miles of 10-in. pipe from Allen, Oklahoma, to Duncan, Oklahoma.

Hauling, unloading and racking approximately 50 miles of 24-in. for Texas Eastern Penn-Jersey from mill at Claymont, Delaware, to points in New Jersey and Pennsylvania.

Unloading from rail cars, hauling to, and stringing on pipe line right-of-way approximately 190 miles of 30-in. pipe for Northern Natural Gas Company, Sunray, Texas, to Ventura, Iowa. Contractor, Midwestern Constructors, Inc., Tulsa.

Unloading from rail cars and stockpiling 48 miles of 24-in. pipe for Texas Eastern Penn-Jersey Transmission Corporation, from A. O. Smith Mill to points in Pennsylvania.

Modern Welding Company, Inc., Owensboro, Kentucky, has completed city distribution systems in Providence and Fulton, Kentucky. Approximately 20 miles of ¾ to 6-in. in Providence, Wesley Embry, superintendent. Approximately 30 miles, ¾ to 8-in. in Fulton, Wallace Mason, superintendent. Company also has jobs in Martin, Tennessee, and Lexington, North Carolina.

H. C. Price Co., Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 355 miles of 30-in. high pressure natural gas pipe line for Gulf Interstate Gas Company starting at a point near Gordonsburg, Tennessee, and extending northeasterly to a point near Catlettsburg, Kentucky. Approximately 75 miles remaining to be completed. Work will begin soon as weather and ground conditions permit.

Company also has general contract covering construction of 57 miles of 30-in. natural gas pipe line for United Fuel Gas Company starting at the Big Sandy River, south of Catlettsburg, Kentucky, and extending in an easterly direction to a point about 6 miles northwest of Charleston, West Virginia.

Williams Brothers Company, 324 National Bank of Tulsa Building, Tulsa, Oklahoma, has contract for 615 miles of 8-in. products line in Alaska for the U. S. Corps of Engineers in a joint venture with McLaughlin, Inc., and Marwell Construction Company.

Company has completed 75 miles of 12-in. line for Oklahoma-Mississippi River Products Pipe Line, Inc., between White River, Arkansas, and Memphis, Tennessee.

Company has contract for 165 miles of 10 through 26-in. lateral lines for Gulf Interstate in Louisiana. O. R. Mitchell is superintendent at Morgan City, Louisiana, field office on one spread, and Red Graves is superintendent on spread two out of Franklin, Louisiana, field office.

Company also has contract for 20 miles of 34-in. line for Creole Petroleum Company in Venezuela. Marvin Jones is superintendent.

Pro-Tekto-Cote Corporation, Box 222, Harvey, Louisiana, is coating and wrapping 73 miles of 2 through 6-in. for City of Dallas, Georgia. Engineering-Construction Company has prime contract. E. O. Vacker is superintendent for Pro-Tekto-Cote.

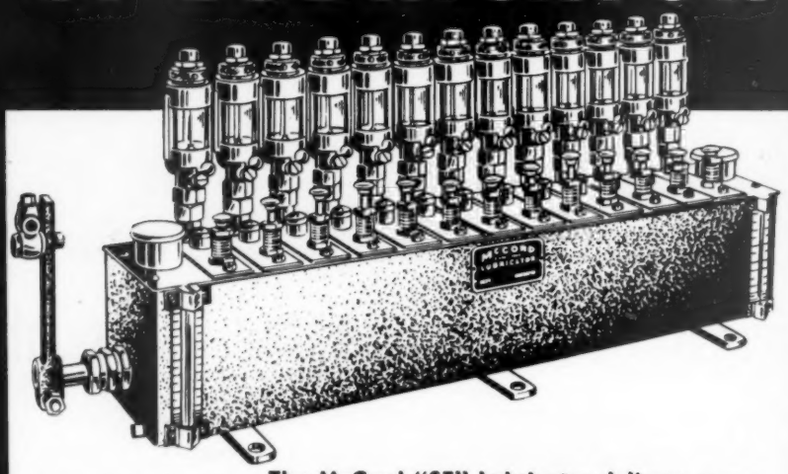
Holdren Construction Company, Box 417, Mt. Vernon, Illinois, is working on 25 miles of ¾ through 4-in. transmission and distribution system in Jasper, Indiana, on sub-contract from Mid-States Construction Company. E. C. Veach is general superintendent, H. W. Randall, superintendent, and Sam C. Wilson, office manager.

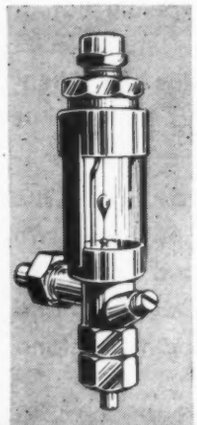
Company also has 67 miles of ¾ through 6-in. yard coating job on subcontract from Mid-States. L. A. Hudson is foreman.

Mid-States Construction Company, Box 417, Mt. Vernon, Illinois, has 32 miles of ¾ through 6-in. gas transmission and distribution system in Huntington, Indiana. E. C. Veach is in charge of work, H. W. Randall, superintendent, and Sam Wilson, office manager.

Pipe Line Construction and Drilling Company, Camp Hill, Pennsylvania, is completing 80 miles of 16-in. for Sinclair between Camden and Linden, New Jersey. Company also has 42 miles of 26-in. for Seaboard in Maryland and Virginia, no starting date announced. R. B. O'Neal, Meril Fandray, Lee Ross, and Curt Steepleton are superintendents.

McCORD Tubular "Clearsite" Feed
SF LUBRICATOR





The McCord "SF" Lubricator delivers a predetermined quantity of oil under pressure at regular intervals to cylinders or bearings. A new improved tubular clearsight feed, a McCord development, shows delivery and quantity of oil. It may be cleaned without removing from pump. Other McCord advantages are easy removal of pump units, welded steel tanks, wide variety of drives, and a new graduated oil level gauge providing greater visibility. McCord offers you an outstanding lubricator, further improved to provide better service. Deliveries are prompt.

LUBRICATOR DIVISION
McCORD CORPORATION
Detroit 11, Michigan

pipe line personals

Bert Martin

R. A. Hamill

H. H. Anderson

A. F. Terrill

Bert Martin, chief gager for Service Pipe Line Company and one of the leaders in the development of crude oil gaging practices, has retired. **R. A. "Rudy" Hamill** will succeed Martin in the post.

A native of Kansas, Martin began his career in the oil industry at Marshall, Illinois, as office boy for Ohio Oil. He moved to Tulsa in 1912 and has resided there since that time. He joined The Texas Company and later headed that firm's tank table department. In 1932 he became head of Service Pipe Line's gaging department.

Hamill, a native Oklahoman, learned the rudiments of gaging as a boy, accompanying his gager father, **Robert H. Hamill,** during his rounds at Okmulgee, Oklahoma. After graduation from Southeastern Oklahoma State College in 1932, he joined Service at Oklahoma City.

H. H. (Hal) Anderson completed his special service as vice president and general manager of Trans Mountain Oil Pipe Line Company on April 30. **A. F. Terrill** has been appointed to the post. Anderson, who retired in 1952 after more than 35 years of widely varied service with Shell Oil in the United States and Mexico, was employed temporarily by Trans Mountain to select, train and manage an all-Canadian staff to operate the new pipe line system. He also served as a member of the construction committee. Terrill came to Trans Mountain as a senior aide to Anderson and as assistant general manager directed the hydraulic testing of the new line and headed up the operating department. He came to Trans Mountain Oil Pipe Line Company after he had retired from a career of 32 years with Shell Pipe Line Corporation.

P. N. Templeton

C. C. Mount

J. E. Boice

J. B. Saunders, Jr.

Paul N. Templeton, secretary and tariff man of Magnolia Pipe Line Company, has been elected to that company's board of directors. Templeton, a native of Waxahachie, Texas, has been with Magnolia since 1925.

Conrad C. Mount, Oklahoma City attorney, has been elected vice president, director, and general counsel of Cities Service Gas Company by the firm's board of directors. He will occupy a post left vacant by **Glenn W. Clark** when he became president of Cities Service Gas in 1952. Mount is a native of Texas and a graduate of the University of Oklahoma and Harvard Law School.

D. L. Cornell has been named chief engineer of Tuscarora Pipe Line Company, Ltd. Cornell is a graduate of West Virginia University and has been with Tuscarora approximately eight years.

John E. Boice, who recently retired as chief of the pipe line engineering and materials branch of the PAD after more than 40 years of government service, has been appointed to the newly created post of assistant secretary of the Committee For Pipe Line Companies, with offices in Washington, D. C.

J. B. Saunders, Jr., Houston, Texas, president of Triangle Refineries, Inc., has been elected vice president of Texas Eastern Transmission Corporation. His election is part of TE's expansion of its top executive staff. He was born in Hillsboro, Texas, and shortly thereafter moved to Sapulpa, in the heart of the Oklahoma oil fields. Saunders has been active in the oil business since 1922.

Raymond F. Hadley has been named chief engineer of the products lines department of Sun Pipe Line Company. **Louis M. Miller** has been named assistant chief engineer and **Robert C. Greer, Jr.,** has been named construction engineer. Hadley was formerly electrical engineer, Miller was mechanical engineer, and Greer, civil engineer.

C. H. M. Burnham, until recently vice president in charge of engineering of Panhandle Eastern Pipe Line Company, has entered the consulting engineering field, with an office at Merriam, Kansas. Burnham is just now rounding out his 38th year in the natural gas industry. Following graduation in 1916 from Ohio State University, he was associated with the Ohio Fuel Supply Company, Henry L. Doherty & Company, Colorado-Wyoming Gas Company, Cities Service, Coast Exploration, and Panhandle Eastern. With the latter, he served as natural gas engineer, chief engineer, and vice president in charge of engineering.

New members of the Pipe Liners Club of Tulsa are **J. E. Hewson,** Foxboro Company; **P. O. Teter,** Cities Service Pipe Line; **Harvey E. Baber,** Oklahoma Mississippi River Products Line; **Shep F. Miers,** Southwest Supply Company, and **A. N. Horne** (honorary member), The Texas Empire Pipe Line Company.

Joseph L. Seger, president of Interstate Oil Pipe Line Company, Shreveport, has announced his resignation effective June 1. Seger, recently elected as vice president and director of The Carter Oil Company, effective also June 1, will continue to serve as director of Interstate.

George A. Wilson has been elected president of the pipe line company to succeed Seger. Wilson, director of supply and transportation for the PAD during World War II and president of Interstate Natural Gas Company from 1946 until December, 1953, is currently special assistant to the coordinator of transportation of Standard Oil Company (New Jersey).

Jac A. Cushman, editor of the AGA Monthly, has transferred to the group's public information bureau to help organize a public relations program. He has been succeeded as editor of the monthly magazine by **Vaughan O'Brien.**

Harold C. Price, president of H. C. Price Company, Bartlesville, Oklahoma, has returned from an extended business trip through southwestern Europe. Price spent considerable time in Madrid, Spain, and also visited Lisbon, Portugal and Paris, France.

Walter H. Kurdelski, sales manager, Michigan Consolidated Gas Company, Grand Rapids, Michigan, has been elected chairman of the residential gas section of the American Gas Association. Kurdelski will succeed **Raymond Little,** who has resigned to become director of sales promotion of the Gas Appliance Manufacturers Association.

Kurdelski joined the Michigan Consolidated Gas Company in 1932. He was recently appointed district sales manager for Michigan Consolidated Gas Company.

Pipe Line Personals

Millard K. Neptune, president of Platte Pipe Line Company, will resign from that company on July 1 to become president of Egyptian American Oil Company, with headquarters in Egypt. Egyptian American Oil Company will operate a 75,000-sq mile petroleum concession recently granted by the Egyptian government to a group of American oil companies.

Ralph Moore, who has been vice president of Platte, will succeed Neptune as president of Platte Pipe Line.

Prior to becoming president of Platte, Neptune had been active in the petroleum industry with Phillips, Continental Oil Company, and the Federal Government. He began with Phillips as a laborer, and his last position with that company was as assistant manager in Venezuela. He left Phillips in 1948, to become manager of Continental Oil Company's Foreign Department. In June 1951, he became president of Platte. He holds degrees in engineering and law from the University of Oklahoma.

Moore was with the Sinclair companies for 22 years before going with Platte when it was organized in 1950.

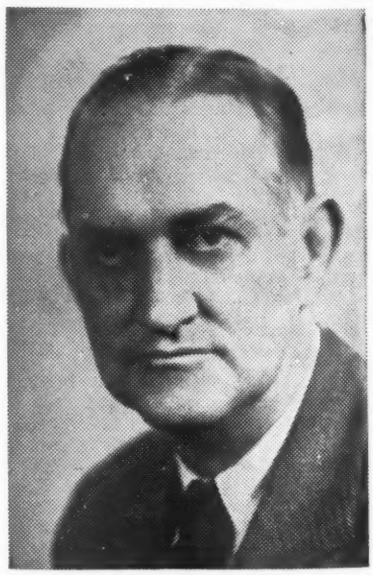
Paul F. Hoots, assistant to the president, New Orleans Public Service, Inc., has been appointed vice-chairman of the American Gas Association Rate Committee. Hoots will aid **George A. Morgan,** The Peoples Gas Light and Coke Company, Chicago, chairman of the AGA Rate Committee, in conducting the operation of the committee. Principal responsibility of the rate committee is to make studies of various costs involved in supplying gas to different classes of customers and to recommend forms of rates designed to meet most equitable distribution of such costs and at the same time to secure adequate and just revenue.

Tom H. Wheat, corporate secretary, Transcontinental Gas Pipe Line Corporation, Houston, Texas, has been appointed vice chairman of the corporate secretaries committee of the American Gas Association. He will assist **B. H. Harper,** secretary, Northern Natural Gas Company, Omaha, Nebraska, chairman of the Corporate Secretaries Committee. The chief responsibility of the committee is to study and develop methods for meeting the problems of corporate secretaries within the gas industry. Wheat has been with Transcontinental Gas Pipe Line Corporation since the company was founded in 1948 and is its oldest employee.

Richard W. Camp, vice president of Consolidated Gas Utilities Corporation,

Richard W. Camp

has been elected president of the company, succeeding **Norman Hirschfield,** who has resigned to become president of SNG Industries of Oklahoma City, Okla-

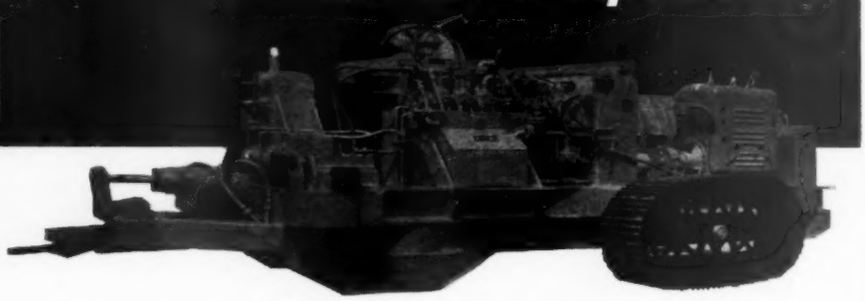


Curtis B. Day

homa. **Curtis B. Day,** who has served as general manager in charge of operations, has been elected vice president.

first With Big Inch Smooth Bends . . . In Performance!

. . . The CINCH Pipe Bender



Features for Greater speed and Easier handling:

- Automatic Hydraulic Wedge-Type Pin-Up Slide
- Extra Large Piston Rams and Return Oil Lines
- Hydraulic Lift Tongue and Tulsa Winch
- Athey Tracks (optional)

There's no better method for bending pipe smoothly and evenly than with hydraulically exerted cold compression as provided by The Cinch Bender. Contractors agree that Cinch provides speed, economy, and safe pipe bending right on the job. So—

If you're a pipeline owner or contractor desiring top performance, insist on the product which pioneered and continued to improve smooth bending in big inch pipe . . . Cinch!

THE "CINCH PIPE BENDER" MAKES PIPE BENDING A CINCH

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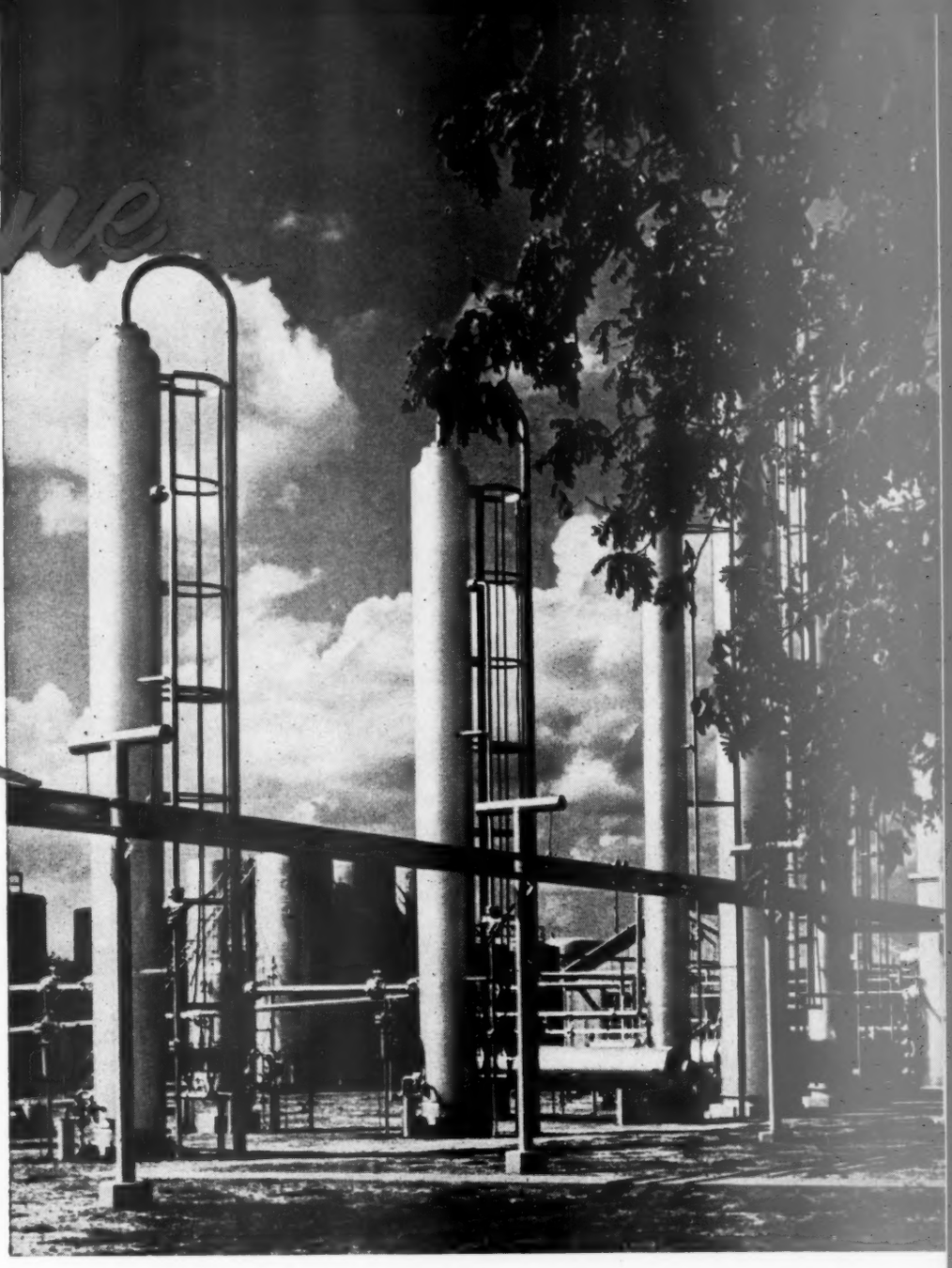

• Whenever the oil search comes up with a major strike of condensate; recovery must take place on the spot and the industry widens its processing skyline by calling for the skill of Wyatt fabrication.

MANUFACTURERS AND ERECTORS SINCE 1913

XUM

This new coating and wrapping machine is powered by an International Gasoline Engine — equipped with electric starter, spray type shoes, and heavy duty transmissions and clutches.

A NEW MEANING OF THE WORD SERVICE

THE FIRST NEW COATING AND WRAPPING FEATURE IN YEARS

This featured V-type machined chain plate prevents breakage of glass wrap and light weight felt. It eliminates *"wobbling"* of chain plate and assures a uniform wrapping job.

WE ARE READY TO SERVE YOU NOW

with the following equipment and supplies.

- Line travel or stationary coating and wrapping machines.
- Line travel or stationary counter rotating head, cleaning and priming machines.
- Asphalt kettles, 17-25 and 30 barrel capacities, improved design, sweep and propeller agitated, 8 feet over-all width for easy hauling.
- Lowering-in belts, welding clamps, Holiday Detectors.
- Pipe cradles, hooks, blocks, pipe straighteners.
- Beveling machines, bending shoes, pipe line locators.
- Miscellaneous welding supplies and hand tools.

Call, write or wire for immediate information on our pipe line equipment and supplies. You'll know then the real meaning of the word service.

MORRIS-YOUNG-OWENS CO.

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HOUSTON, TEXAS

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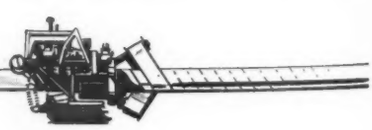
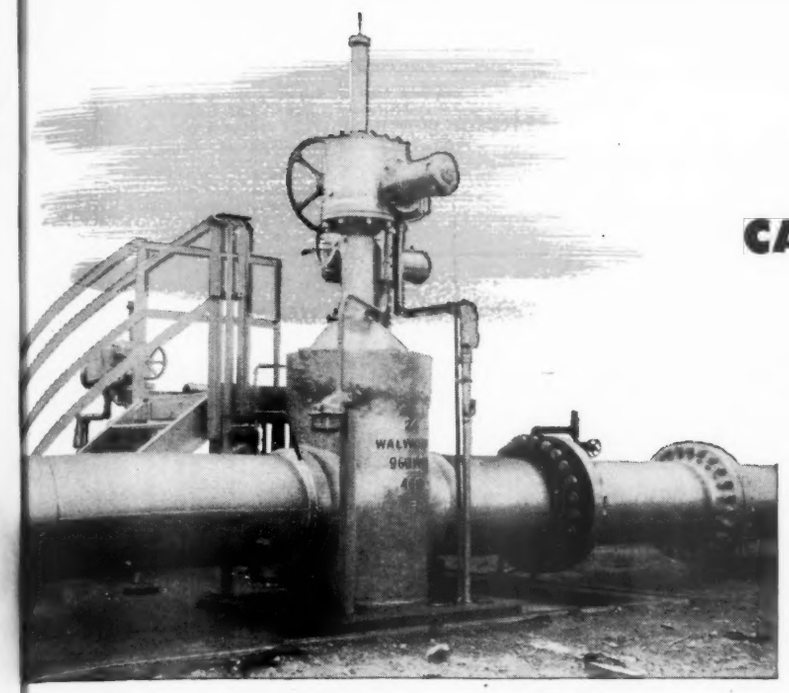


To obtain more information on products advertised see page E-57

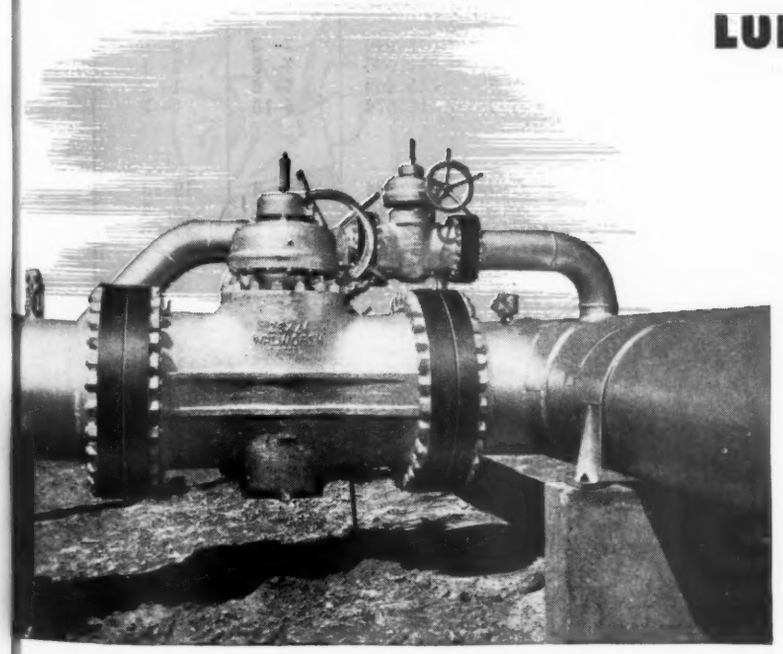


CAST STEEL GATE VALVES

A 24-inch Walworth Type 49 Series 400, 960 WOG, Cast Steel Gate Valve with welding ends and motor operating device, on a pipeline handling crude petroleum.

Walworth Type 49 Valves are especially designed for service on pipelines handling gas, refined products, or crude oil. Through-port construction allows free passage of pigs and scrapers. These valves do not require any internal lubrication and may be installed without regard to direction of flow.

WALWORTH makes both for pipeline service



LUBRICATED PLUG VALVES

A Walworth 26 x 24-inch, 1000 WOG Cast Steel, Worm Gear Operated, Flanged, Lubricated Plug Valve installed on main line discharge of a gas pipeline.

Walworth Lubricated Plug Valves afford quick, easy operation . . . a quarter turn gives full, direct port opening. The lapped surfaces of the plug and body, plus the seal afforded by the lubricant, assure a tight, leakproof valve.

Always use Walworth lubricants in Walworth Lubricated Plug Valves.

Let us help you with your pipeline valve problems. Because we make *both* gate valves *and* lubricated plug valves, we can give you an unbiased recommendation regarding the best type of pipeline valve for your particular need. See your nearest Walworth distributor, local Walworth representative or write: ***Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.***

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RISE IN FLUID LEVEL, ETC., DUE TO RUNNING 2½-IN. EXTERNAL-UPSET TUBING IN WELL FLUID

Diameter of outer string or open hole, in	Internal diameter of outer string or open hole, in	Volume[1] contained in outer string or open hole		Volume[1] contained in annular space		Volume[1] in well bore when tubing is in hole (volume in annulus plus volume in tubing)		For every 100 ft. of tubing run in fluid, fluid level will be raised:	
		gal.	bbl.	gal.	bbl.	gal.	bbl.	in annular space when lower end of tubing is closed, ft.-in.	in well bore when lower end of tubing is open, ft.-in.
Tubing strings									
Non-upset									
4	3.958	63.92	1.522	29.73	0.708	54.04	1.287	115- 0	18- 3
Upset									
4	3.958	63.92	1.522	29.73	0.708	54.04	1.287	115- 0	18- 3
Casing strings[2]									
4½	4.090	68.25	1.625	34.06	0.811	58.37	1.390	100- 5	16-10
4½	3.920	62.69	1.493	28.50	.679	52.81	1.257	120- 0	18- 8
5	4.560	84.84	2.020	50.65	1.206	74.96	1.785	67- 6	13- 2
5	4.276	74.60	1.776	40.41	0.962	64.72	1.541	84- 7	15- 2
5½	5.044	103.8	2.741	69.61	1.657	93.92	2.236	49- 1	10- 6
5½	4.670	88.98	2.119	54.79	1.305	79.10	1.883	62- 5	12- 5
6	5.524	124.5	2.964	90.31	2.150	114.6	2.729	37-10	8- 7
6	5.240	112.0	2.667	77.81	1.853	102.1	2.431	43-11	9- 8
6⅝	6.135	153.6	3.657	119.4	2.843	143.7	3.421	28- 8	6-10
6⅝	5.675	131.4	3.129	97.21	2.315	121.5	2.893	35- 2	8- 1
7	6.538	174.4	4.152	140.2	3.338	164.5	3.917	24- 5	6- 0
7	5.920	143.0	3.405	108.8	2.590	133.1	3.169	31- 5	7- 5
7⅝	7.125	207.1	4.931	172.9	4.117	197.2	4.695	19- 9	5- 0
7⅝	6.625	179.1	4.624	144.9	3.450	169.2	4.029	23- 7	5-10
8⅝	8.097	267.5	6.369	233.3	5.555	257.6	6.133	14- 8	3-10
8⅝	7.511	230.2	5.481	196.0	4.667	220.3	5.245	17- 5	4- 6
9⅝	9.063	335.1	7.979	300.9	7.164	325.2	7.743	11- 4	3- 0
9⅝	8.535	297.2	7.076	263.0	6.262	287.3	6.840	13- 0	3- 5
10¾	10.192	423.8	10.090	389.6	9.276	413.9	9.855	8- 9	2- 5
10¾	9.760	388.7	9.255	354.5	8.440	378.8	9.019	9- 8	2- 7
11¾	11.150	507.2	12.076	473.0	11.262	497.3	11.840	7- 3	2- 0
11¾	10.772	473.4	11.271	439.2	10.457	463.5	11.036	7- 9	2- 1
13⅜	12.715	659.6	15.705	625.4	14.890	649.7	15.469	5- 6	1- 6
13⅜	12.347	622.0	14.810	587.8	13.995	612.1	14.574	5-10	1- 7
Open hole (bit size)[3]									
3⅞	3.875	61.27	1.459	27.08	0.645	51.39	1.224	126- 3	19-10
4¼	4.250	73.70	1.755	39.51	0.941	63.82	1.520	86- 6	15- 5
4¾	4.750	92.06	2.192	57.87	1.378	82.18	1.957	59- 1	12- 0
5⅝	5.625	131.4	3.129	97.21	2.315	121.5	2.893	35- 2	8- 1
6	6.000	146.9	3.498	112.7	2.683	137.0	3.262	30- 4	7- 2
6⅛	6.125	153.1	3.645	118.9	2.831	143.2	3.410	28- 9	6-10
6½	6.500	172.4	4.105	138.2	3.290	162.5	3.869	24- 9	6- 1
6¾	6.750	185.9	4.426	151.7	3.612	176.0	4.190	22- 6	5- 7
7	7.000	199.9	4.760	165.7	3.945	190.0	4.524	20- 4	5- 2
7⅞[4]	7.500	229.5	5.464	195.3	4.650	219.6	5.229	17- 6	4- 6
7¾[4]	7.750	245.1	5.836	210.9	5.021	235.2	5.600	16- 3	4- 2
8½[4]	8.500	284.8	7.019	260.6	6.205	284.9	6.783	13- 1	3- 5
9¾[4]	9.750	387.9	9.236	353.7	8.421	378.0	9.000	9- 8	2- 7
10⅝	10.625	460.6	10.967	426.4	10.152	450.7	10.731	8- 0	2- 2

The 2½-in. external-upset tubing has a calculated weight of 6.44 lb. per ft. (including a coupling spaced every 20 ft.). The volume displaced by 100 ft. of tubing and 5 couplings: (1) by the steel itself (with end of tubing open), 9.841 gal. or 0.2343 bbl.; (2) by the pipe (with lower end of tubing closed), 34.19 gal. or 0.8140 bbl. The volume contained within 100 ft. of the tubing is 24.31 gal. or 0.5788 bbl.

[1]All volume figures are based on 100 ft. of depth; multiply to convert to other depths or lengths. For example, if the depth or length is 5196 ft., multiply by 51.96.

[2]Only maximum and minimum weights of pipe are shown for each casing size.

[3]Variation in diameter of open hole due to caving, etc., is disregarded.

[4]This diameter is an average of the two bit sizes ⅛ in. larger and smaller, respectively.

Table suggested by George B. Rice, Butler & Horne Drilling Co., Dallas, Texas.

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STATIC PRESSURES, LB. PER SQ. IN. ABS., CORRESPONDING TO L-10 CHART READINGS

L-10 Chart Reading, P_L	Range of static pressure element, lb. per sq. in. (R_S)										
	50	100	250	500	1000	1500	2000	2500	3000	4000	5000
1.0	0.500	1.000	2.500	5.00	10.00	15.00	20.00	25.00	30.00	40.00	50.0
1.5	1.125	2.250	5.625	11.25	22.50	33.75	45.00	56.25	67.50	90.00	112.5
2.0	2.000	4.000	10.00	20.00	40.00	60.00	80.00	100.0	120.0	160.0	200.0
2.5	3.125	6.25	15.63	31.25	62.50	93.75	125.0	156.3	187.5	250.0	312.5
3.0	4.500	9.000	22.50	45.00	90.00	135.0	180.0	225.0	270.0	360.0	450.0
.1	4.805	9.160	24.03	48.05	96.10	144.2	192.2	240.3	288.3	384.4	480.5
.2	5.120	10.24	25.60	51.20	102.4	153.6	204.8	256.0	307.2	409.6	512.0
.3	5.445	10.89	27.23	54.45	108.9	163.4	217.8	272.3	326.7	435.6	544.5
.4	5.780	11.56	28.90	57.80	115.6	173.4	231.2	289.0	346.8	462.4	578.0
3.5	6.125	12.25	30.63	61.25	122.5	183.8	245.0	306.3	367.5	490.0	612.5
.6	6.480	12.96	32.40	64.80	129.6	194.4	259.2	324.0	388.8	518.4	648.0
.7	6.845	13.69	34.23	68.45	136.9	205.4	273.8	342.3	410.7	547.6	684.5
.8	7.220	14.44	36.10	72.20	144.4	216.6	288.8	361.0	433.2	577.6	722.0
.9	7.605	15.21	38.03	76.05	152.1	228.2	304.2	380.3	456.3	608.4	760.5
4.0	8.000	16.00	40.00	80.00	160.0	240.0	320.0	400.0	480.0	640.0	800.0
.1	8.405	16.81	42.03	84.05	168.1	252.2	336.2	420.3	504.3	672.4	840.5
.2	8.820	17.64	44.10	88.20	176.4	264.6	352.8	441.0	592.2	705.6	882.0
.3	9.245	18.49	46.20	92.45	184.9	277.4	369.8	462.3	554.7	739.6	924.5
.4	9.680	19.36	48.40	96.80	193.6	290.4	387.2	484.0	580.8	774.4	968.0
4.5	10.13	20.25	50.63	101.3	202.5	303.8	405.0	506.3	607.5	810.0	1013.
.6	10.58	21.16	52.90	105.8	211.6	317.4	423.2	529.0	634.8	846.4	1058.
.7	11.05	22.19	55.23	110.5	221.9	331.4	441.8	552.3	662.7	883.6	1105.
.8	11.52	23.04	57.60	115.2	230.4	345.6	460.8	576.0	691.2	921.6	1152.
.9	12.01	24.01	60.03	120.1	240.1	360.2	480.2	600.3	720.3	960.4	1201.
5.0	12.50	25.00	62.50	125.0	250.0	375.0	500.0	625.0	750.0	1000.	1250.
.1	13.01	26.01	65.03	130.1	260.1	390.2	520.2	650.3	780.3	1040.	1301.
.2	13.52	27.04	67.60	135.2	270.4	405.6	540.8	676.0	811.2	1082.	1352.
.3	14.05	28.09	70.23	140.5	280.9	421.4	561.8	702.3	842.7	1124.	1405.
.4	14.58	29.16	72.90	145.8	291.6	437.4	583.2	729.0	874.8	1166.	1458.
5.5	15.13	30.25	75.63	151.3	302.5	453.8	605.0	756.3	907.5	1210.	1513.
.6	15.68	31.36	78.40	156.8	313.6	470.4	627.2	784.0	940.8	1254.	1568.
.7	16.25	32.49	81.23	162.5	324.9	487.4	649.8	812.3	974.7	1300.	1625.
.8	16.82	33.64	84.10	168.2	336.4	504.6	672.8	841.0	1009.	1346.	1682.
.9	17.41	34.81	87.03	174.1	348.1	522.2	696.2	870.3	1044.	1392.	1741.
6.0	18.00	36.00	90.00	180.0	360.0	540.0	720.0	900.0	1080.	1440.	1800.
.1	18.61	37.21	93.03	186.1	372.1	558.2	744.2	930.3	1116.	1488.	1861.
.2	19.22	38.44	96.10	192.2	384.4	576.6	768.8	961.0	1153.	1538.	1922.
.3	19.85	39.69	99.23	198.5	396.9	595.4	793.8	992.3	1191.	1588.	1985.
.4	20.48	40.96	102.4	204.8	409.6	614.4	819.2	1024.	1229.	1638.	2048.
6.5	21.13	42.25	105.6	211.3	422.5	633.8	845.0	1056.	1268.	1690.	2113.
.6	21.78	43.56	108.9	217.8	435.6	653.4	871.2	1089.	1307.	1742.	2178.
.7	22.45	44.89	112.2	224.5	448.9	673.4	897.8	1122.	1347.	1796.	2245.
.8	23.12	46.24	115.6	231.2	462.4	693.6	924.8	1156.	1387.	1850.	2312.
.9	23.81	47.61	119.0	238.1	476.1	714.2	952.2	1190.	1428.	1904.	2381.
7.0	24.50	49.00	122.5	245.0	490.0	735.0	980.0	1225.	1470.	1960.	2450.
.2	25.92	51.84	129.6	259.2	518.4	777.6	1037.	1296.	1555.	2074.	2592.
.4	27.38	54.76	136.9	273.8	547.6	821.4	1095.	1369.	1643.	2190.	2738.
.6	28.88	57.76	144.4	288.8	577.6	866.4	1155.	1444.	1733.	2310.	2888.
.8	30.42	60.84	152.1	304.2	608.4	912.6	1217.	1521.	1825.	2434.	3042.
8.0	32.00	64.00	160.0	320.0	640.0	960.0	1280.	1600.	1920.	2560.	3200.
.2	33.62	67.24	168.1	336.2	672.4	1009.	1345.	1681.	2017.	2690.	3362.
.4	35.28	70.56	176.4	352.8	705.6	1058.	1411.	1764.	2117.	2822.	3528.
.6	36.98	73.96	184.9	369.8	739.6	1109.	1479.	1849.	2219.	2958.	3698.
.8	38.72	77.44	193.6	387.2	774.4	1162.	1549.	1936.	2323.	3098.	3872.
9.0	40.50	81.00	202.5	405.0	810.0	1215.	1620.	2025.	2430.	3240.	4050.
.2	42.32	84.64	211.6	423.2	846.4	1270.	1693.	2116.	2539.	3386.	4232.
.4	44.18	88.36	220.9	441.8	883.6	1325.	1767.	2209.	2651.	3534.	4418.
.6	46.08	92.16	230.4	460.8	921.6	1382.	1843.	2304.	2765.	3686.	4608.
.8	48.02	96.04	240.1	480.2	960.4	1441.	1921.	2401.	2881.	3842.	4802.
10.0	50.00	100.0	250.0	500.0	1000.	1500.	2000.	2500.	3000.	4000.	5000.

Inasmuch as square root (L-10) charts do not record pressures in lb. per sq. in. directly, it is necessary to resort to the following formula to convert the L-10 readings to lb. per sq. in. (absolute):

$$P_A = P^2_L R_S \div 100$$

where: P_A = static pressure, lb. per sq. in. (abs.)
P_L = static pressure reading on (L-10) chart
R_S = range of static pressure element

To convert P_A to gauge pressure, subtract the atmospheric pressure in vicinity from above values of P_A.

Deduct atmospheric pressure in comparing meter reading with indicating gauge reading.

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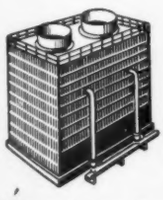

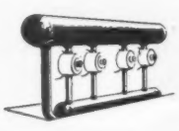
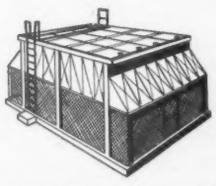
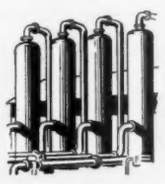
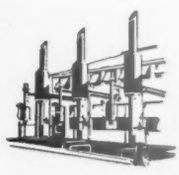

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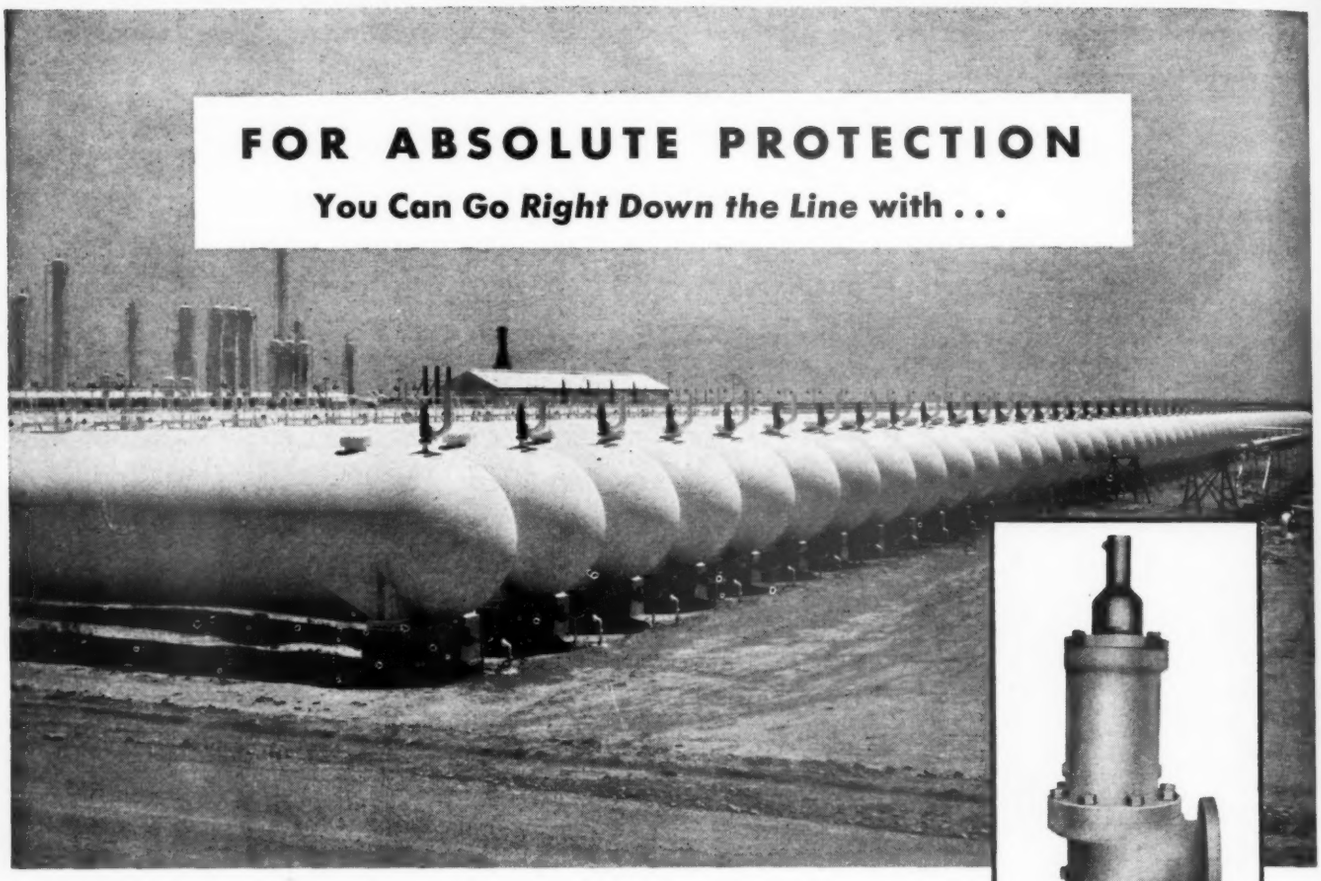

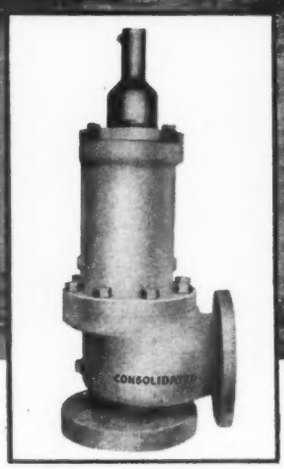

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Clamp Gate Valves

Low in first cost, as well as in upkeep . . . and look at their wide utility—

Use Crane Clamp Gate Valves for steam; hot and cold water; crude, fuel, and lubricating oil; air, gas, and gasoline service.

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You'll find Crane Clamp Gate Valves extra rugged, with a strong reinforced body and husky stem. Their compact design means a better fit for more places . . . a saving on piping in many cases. And because of the simplified clamp construction, these valves enjoy wide favor where frequent cleanout is essential. The bonnet assembly and wedge disc lift out easily—the body stays in the line. Reassembling is no problem—the bonnet joint makes up tight and stays tight.

Wide choice of regular patterns, all-iron or brass trimmed. On inside screw all-iron valves, an improved self-draining bonnet prevents entrapment of line fluids in the bonnet—protects the threads, keeps the stem working smoothly. Send for Folder AD 1667 or ask your Crane Representative for full details.

Crane Wedge Disc Clamp Gate Valves come in OS&Y, inside screw, and quick-opening patterns, all-iron or brass trimmed, screwed or flanged end. Sizes up to 4 in. Working pressures up to 150 p.s.i. saturated steam, 225 p.s.i. cold service.

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The gas line Cortemaggiore-Torino crossing the Ticino River. — *Courtesy Ente Nazionale Idrocarburi.*

P 136.

Italian Refining Capacity Outpaces Demand

Proposed petroleum laws might draw needed foreign capital to develop oil and gas production

FERNANDO DE MATTIA

OIL and gas seeps are scattered throughout Italy being especially prevalent in those regions of the Apennines stretching toward the valley of the Po, and have been well known ever since ancient times.

These emanations, kindled by chance, formed burning fountains to whose existence the establishment of towns was once linked. Among these was Agrigento in Sicily, well known on account of its apparitions of petroleum. This liquid, which was picked up and sold as "oil from Agrigento", was so widely and variously used by the inhabitants, that Pliny, the famous Roman historian, wrote in his "Natural History": "... gignitur etiam pingue oleique liquoris in Sicilia, Agragantina fonte, inficiens rivum; incolae ... rituntur eo ad lucernarum lumina, olei vice, item ad scabiem jumentorum." (Nat. Hist. XXXV-51-).

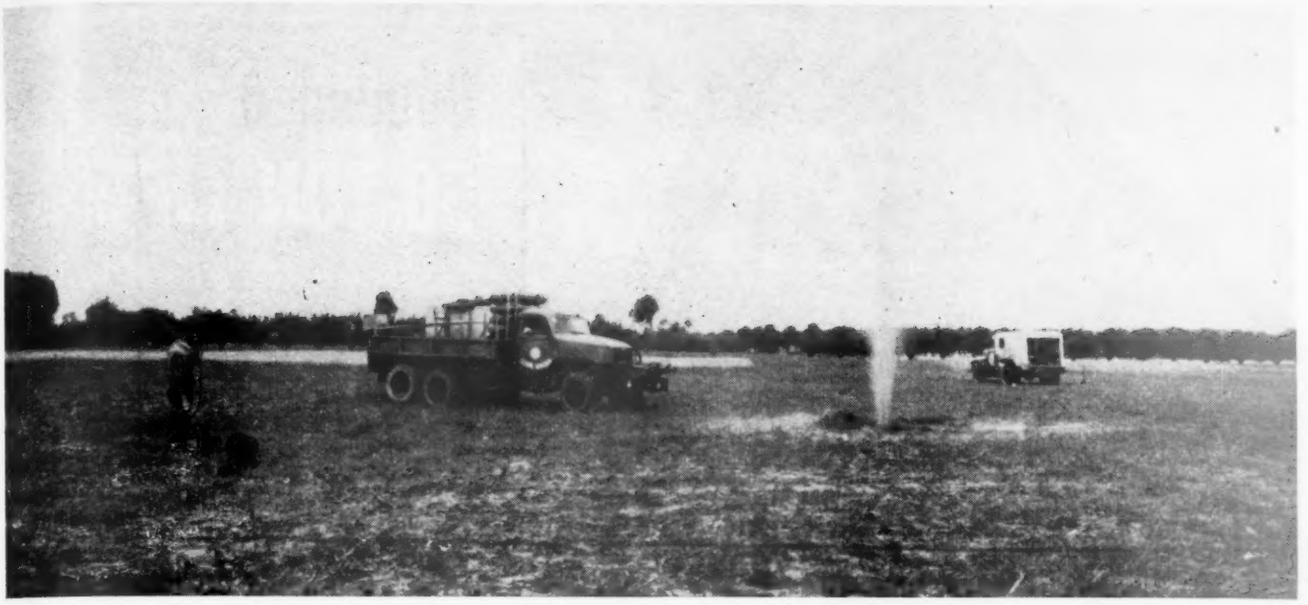
In Imperial Rome, petroleum baths seem to have been quite fashionable; in fact, the thermae of Nero are said to have offered such baths. Remarkable is also the list of diseases which, according to Pliny, found their antidotes in petroliferous products. Bitumen in particular was thought to have the power of stopping hemorrahages, hastening the cicatrization of wounds, fighting successfully against cataracts, leprosy, itching, and even curing gout!

Nor was the use of petroleum as a medicine a characteristic peculiar to the Roman Era. Toward 1875, for instance, in Salsomaggiore, a resort well known for its thermal treatments, the salt springs were exploited at first for the production of coarse salt, but a few casks of petroleum were dug out to be used as a vermifuge for children.

There was a belief at that time that by rubbing the children's chest and nostrils with that liquid, worms would be kept at bay. As the salt mine owners did not sell the petroleum, whoever wished to have some would bring a bottle of olive oil and exchange it for a bottle of petroleum. Thus would the anxious mothers supply themselves with the medicine against worms. The salt mine owners, for their part, used the fuel for lighting shops. In fact, oil lamps were then common.

Nevertheless, in spite of these early records, and the fact that petroleum was already being mined from the fields of Velleja, Montechino, Centopozzi,

EXCLUSIVE



Padana Valley, Italy. TNT shot exploding hurls geyser of sand. — *Courtesy Ente Nazionale Idrocarburi.*

Vallezza, before 1875, thus making Italy, chronologically, the fifth producer of petroleum, after the United States, Russia, Romania, and Canada, it was 1930 before the production of hydrocarbons in significant quantities began. There had been considerable activity before this time, but it had led only to the development of numerous small fields, especially in the region around Parma.

In order to encourage private initiative, the government decided in 1911 to grant prizes for exploration and to give up any royalty on the production. The results, though, were not encouraging. In 1926 the government decided to study problems concerning the petroleum industry and research activities, and created the AGIP (Italian General Petroleum Corporation).

Within a short time, the AGIP research department showed the first successful results through discoveries in Fontevivo, Bellena, and Podenzano.

Later AGIP operations were aided by the introduction, in 1933, of the seismic method, which led, besides other improvements, to the discovery of the gas field in Lodi. In short, within 10 years, the results achieved by the AGIP in the field of gas were undoubtedly encouraging: 459,000,000 cu ft in 1936.

Outbreak of the second World War in 1939 brought about a halt which lasted all through the war. After the liberation, activities were resumed and the AGIP discovered a small field at S. Giorgio in 1942, and another one at Caviaga in 1946. Such discoveries were important, both because they disclosed the importance of the gas reserve, and because they confirmed the belief that the upper Miocene layers could be productive at 4250 ft.

After Caviaga, there followed a sequence of successful discoveries: In 1947 Ripalta, in 1948 Cortemaggiore, in 1949 Conegliano Laudense, in 1950 Bordolano, in 1952 Correggio, and in 1953 Imola, Verolanuova, Faenza. We must emphasize the discovery in Cortemaggiore (gas and petroleum), which was a spur to research development and which supplied a considerable contribution to the supply of fuel in Italy. As a matter of fact, the gas processed in the modern refinery yields daily about 2800 bbl of gasoline and a fairly good amount of LPG. All products of Cortemaggiore are practically free from sulfur.

In the Eastern part of the Po valley (Polesine) there is a lively drilling activity among private individuals. Such region almost can be considered as a single field developed by a thousand or more wells. Wherever one drills, one finds there gas and water. The people of Polesine therefore would joke about it and say that whoever looked for water would find gas. During this last period the most considerable discoveries have taken place near Ferrara, due to operations by the Italian Petroliferous Society—S.P.I.—and the National Hydrocarbon Society—S.I.N.

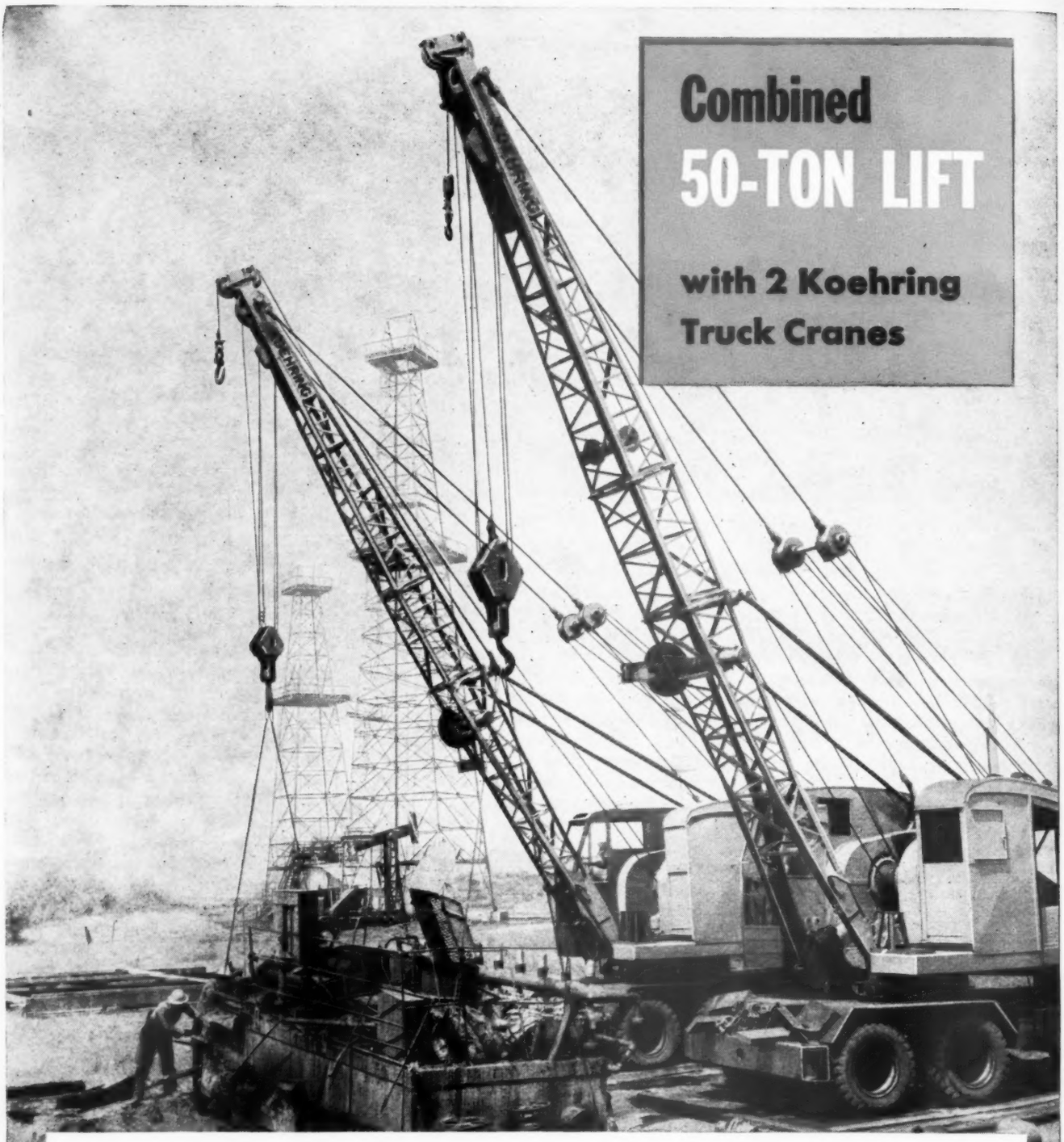
In the Marche, Toscana, Lazio, Abruzzi, Calabria as well, a wide petroliferous research plan is being carried out by the AGIP and such societies as the Edison, Montecatini, Terni, etc. But it is in Sicily that exploratory operations are most active, being made easier by the liberal act issued by the Sicilian Region on March 20, 1950. Such act decrees — among other decisions—that the explorer has the "right" to be granted a concession, not merely a preference. This principle marks an improvement as far as the present mining legislation is concerned, causing such companies as Gulf Oil, MacMillan, and Anglo-Iranian to focus their interest on the Sicilian island.

The American International Fuel and Petroleum Company belonging to Gulf Oil has recently verified the presence of liquid hydrocarbons at 6000 ft in Ragusa. Though concrete data have not yet been issued, the discovery in Ragusa is nevertheless a token of the existence of petroleum in the Sicilian sub-strata.

The D'Arcy Exploration Company, a subsidiary of AIOC, has begun drilling a deep exploratory well at Vittoria. In the Piana of Catania, the ESVAISO, a subsidiary of AGIP, has made tests at shallow depths and found petroliferous structures. Drilling work is a result of a coordinate campaign of geological and geophysical surveying, carried out by aeromagnetic, gravimetric and seismic methods. Research licenses covering about 36 per cent of prospective areas have been granted to foreign societies and the rest to Italian ones (AGIP, Snia-Viscosa, Edison).

Production of oil and gas in Italy is limited at present to the production of gas. Gas production has passed from 3707 MMCF in 1948 to 7238 MMCF in 1953. On the ground of the data available so far, we can say that the government concern has contributed 89.1 per cent to the national output of natural gas in the first quarter of 1953, private concerns in Polesine 10.3 per cent, and the other extractive activities 0.6 per cent. It is to be noted, therefore, that the increase of production is chiefly due to the Government concern activity, which from the 990 MMCF in 1948 has reached 6400 MMCF in 1953.

As far as consumption is concerned, while in past times the greater part of



Combined 50-TON LIFT

with 2 Koehring Truck Cranes

Lifting a heavy mud tank assembly into place, two Koehring 304 Truck Cranes (above) worked as a team . . . exerted a total lift capacity of 50 tons. As the cranes inched the bulky load into position, power-boom lowering provided safe, positive control. Mechanical booster clutch on each crane retained exceptionally accurate "feel" of load during lifting and lowering. On heavy work like this, Koehring 304 booster clutch provides another important advantage. It reduces operating effort . . . requires only one-third to half the lever pull of a straight manual clutch.

This heavy-duty 25-ton crane also converts to dragline, clamshell, pile driver, ¾-yard shovel or hoe . . . is available on rubber-tired truck, cruiser mounting, or heavy-duty crawlers to suit all working conditions in the oil field. Get complete details from your Koehring distributor, or write for your copy of new 36-page 304 catalog.

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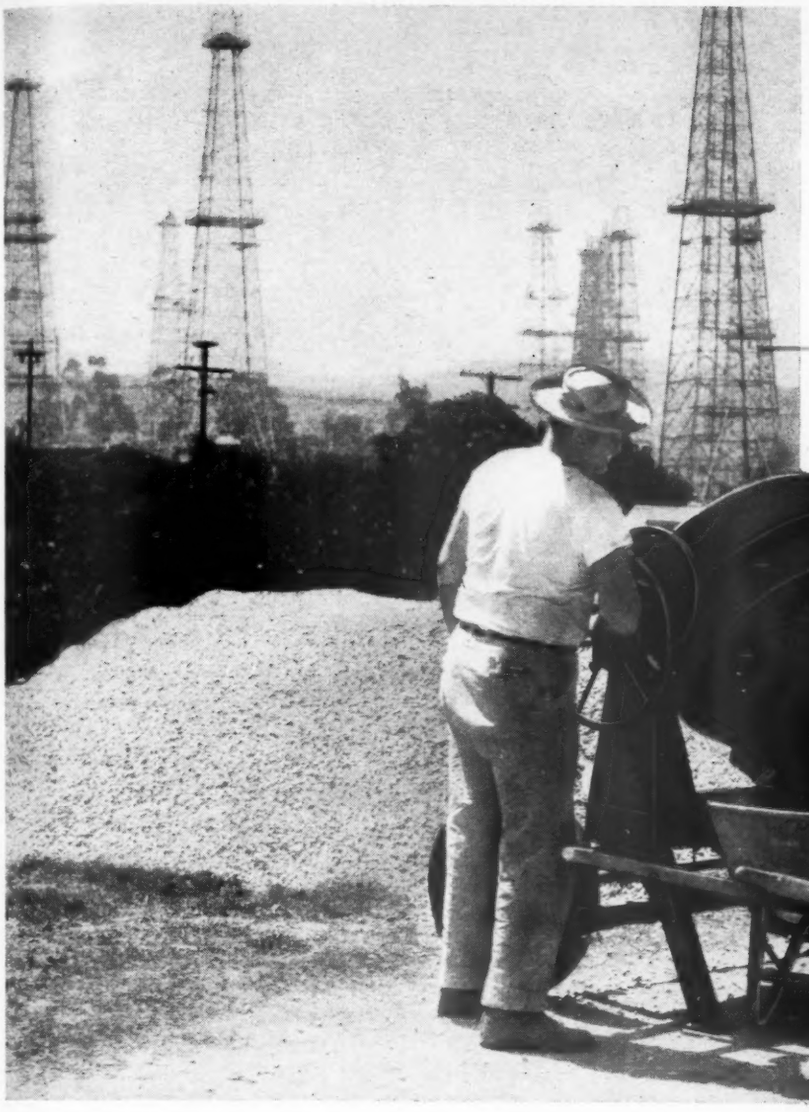
CRANES up to 79½ TONS lift capacities . . . EXCAVATORS ½ to 2½ yards



oil field "handyman"

KWIK-MIX 3½-S DANDIE® SPEEDS MIXING JOBS...

IT'S AS PORTABLE AS A WHEELBARROW....

For pouring footings, laying concrete slabs, and handling all other widely-scattered mixing jobs around refineries, yards, booster stations or drill sites, here's a portable "handyman" that does on-the-spot mixing. Kwik-Mix 3½-S Dandie produces high-quality concrete fast, at low cost, anywhere on your property.

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Kwik-Mix also offers you: 6-S (shown here), 11-S, and 16-S Dandie concrete mixers; and Moto-Bug® . . . 10 cu. ft. power wheelbarrow. Ask your Kwik-Mix distributor for details . . . or write for bulletins.

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In the past men and animals did most of our work, but today methane, the new Italian energy, powers machines.

The productive Cortemaggiore field, discovered in 1948 by AGIP.
— Photos courtesy Ente Nazionale Idrocarburi.

the production was absorbed by vehicles (as a matter of fact, gas was first used in Italy as a carbureting substance), vehicles now use only 13 per cent.

The metallurgic industry is, on the contrary, the one absorbing the greatest amount, about 25 per cent of the material sold; the textile and chemical industries, principally for steam production, respectively 19 per cent and 15 per cent, but it is possible to foretell that, as soon as the two large thermoelectric gas installations in Tavezzano and Piacenza are set to work, consumption will be by far greater; and last, 5 per cent for domestic use and private house heating.

The Author

Fernando De Mattia is doctor of laws at the University of Naples and Advocate. He has been connected with the oil industry in Italy and Somaliland for 18 years and spent many years in Libya, Egypt, Ethiopia, Lebanon, and Greece. He writes for numerous petroleum magazines and other reviews. He has published an informative new book, "The Wonderful World of Petroleum."

Gas lines. The network of gas lines belongs for the greater part to the Government concern which runs it through the SNAM. There is also the system of the AMP — Azienda Metanodotti Padani — controlled by the government. The system is based on large pipe lines constituting the main arteries, from which branch secondary lines that make it possible for gas to be sent to all smaller centers.

On December 31, 1952 the principal gas line system reached 1800 miles and had a capacity of 495,000,000 cu ft daily.

New Petroleum Law Project

We shall mention briefly the new project for a petroleum law, which will cause changes in the old-fashioned legislation now in force. Among the changes of greatest moment, there is an innovation by which whoever has been granted a lease has the right to claim two delays of two years each when he has completed his work plan. He has, moreover, the right to claim a special delay in case a productive zone is discovered, in order to obtain a certain claim to the seeker and to develop a certain research program for overcoming the difficulties of the enterprise. If the permittee discovers the zone, he has the "right" to claim a 20-year grant and two delays of 10 years each, which will enable him to exploit the reserve and amortize the capital he invested.

In order to avoid forestalling, the project emphasizes the fact that the permissions cannot be granted to the single individual or firm for an area of more than 750,000 acres in the whole territory or over 575,000 acres in the same region. Each permission shall not exceed 125,000 acres.

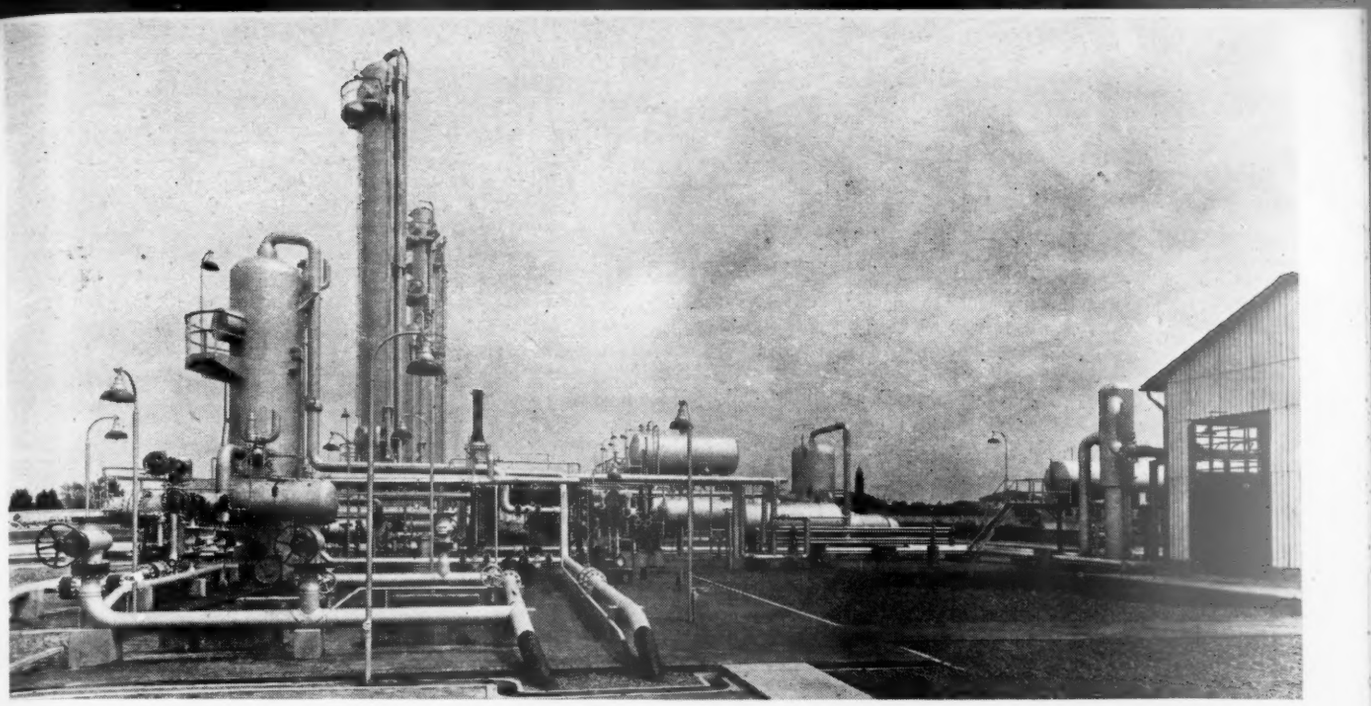
Present Situation in Italy

Petroleum activity in Italy is chiefly represented by a refining industry, which constitutes through the amount of its investments, about $400,000,000 — one of the most important departments of our national economy.

After winding up of the Comitato Ital. Petroli. — a temporary organization instituted in 1943 with the aim of rebuilding what had been destroyed during the war — there are the following groups working at present in Italy: AGIP, Standard N. J., Socony, Caltex, Shell, and several smaller companies.

Activity of these groups, strongly competing with one another, is placed under the control of the executive power, for the carbureting trade takes place under the protection of the "petroli" and "prezzi" offices of the Board of Industry and Trade. Installation of refineries is regulated by the government as well.

In order to coordinate, promote, and put into practice national interest in



Modern Cortemaggiors plant, where natural gasoline and other products are extracted from gas. Dry gas is ultimately used for fuel.
— Courtesy Ente Nazionale Idrocarburi.

oil and gas, the National Hydrocarbon Corporation was created early last year (Ente Nazionale Idrocarburi E.N.I., Act 136, February 20, 1953). It represents a compromise between the two opposite and antithetical tendencies: One supporting absolute freedom of private initiative and the other voting for monopoly in the field of hydrocarbons.

One of the principal tasks the E.N.I. has been given by the law to perform is the research, production, and utilization of hydrocarbons and natural gas in the Italian territory with a patent in the Po Valley, except for the region around Rovigo and Ferrara. In the rest of the territory research is being carried on in competition with the other private companies. To the E.N.I. also has been committed construction and management of gas lines.

Leaving out of consideration all developments and advantages likely to ensue from activity of the E.N.I., the petroleum situation, as we can judge at present, is the following: Italy produces no raw material, and must therefore purchase abroad, especially in the Middle East, the petroleum necessary to the national need of liquid fuel. The value FOB of such supplies can be reckoned at about $100,000,000, a figure which represents little more than 3 per cent of all Italian imports.

We must nevertheless add that the actual money disbursement is not exactly equivalent to $100,000,000, but smaller, for we must deduct first the money which Italian refineries receive as a compensation for work by foreign companies, second, the money obtained for exportation of manufactured products, third, the money spent by motorist tourists, and last, partial supplies of petroleum for special manufacture, made with F.O.A. funds. The sum is therefore reduced to $85 to $90,000,000.

The money difficulties with which all countries in Western Europe are struggling, make it necessary to subordinate the importations of raw material to the availability of funds; consequently, the imports for consumption are controlled through the "drawing-bonds", that is permission to draw out of the refineries the manufactured goods. Naturally this limits the work in the establishments, output capacity of which is by far superior to home consumption and to the possibility of exportation. As a matter of fact, while there is a refinery capacity of 105,000,000 bbl yearly, the consumption and exportation summed together reach only about 70,000,000 bbl. Such a disproportion will increase more and more in the near future, owing to the setting to work of new establishments, the renewal and greater potentiality of those already existing, so that the capacity of the Italian refineries will reach 126,000,000 bbl in 1954. There is one more obstacle that makes the economy of the Italian petroleum industry even more severe, namely the duty of those intangible supplies implying the idleness of tens of million dollars.

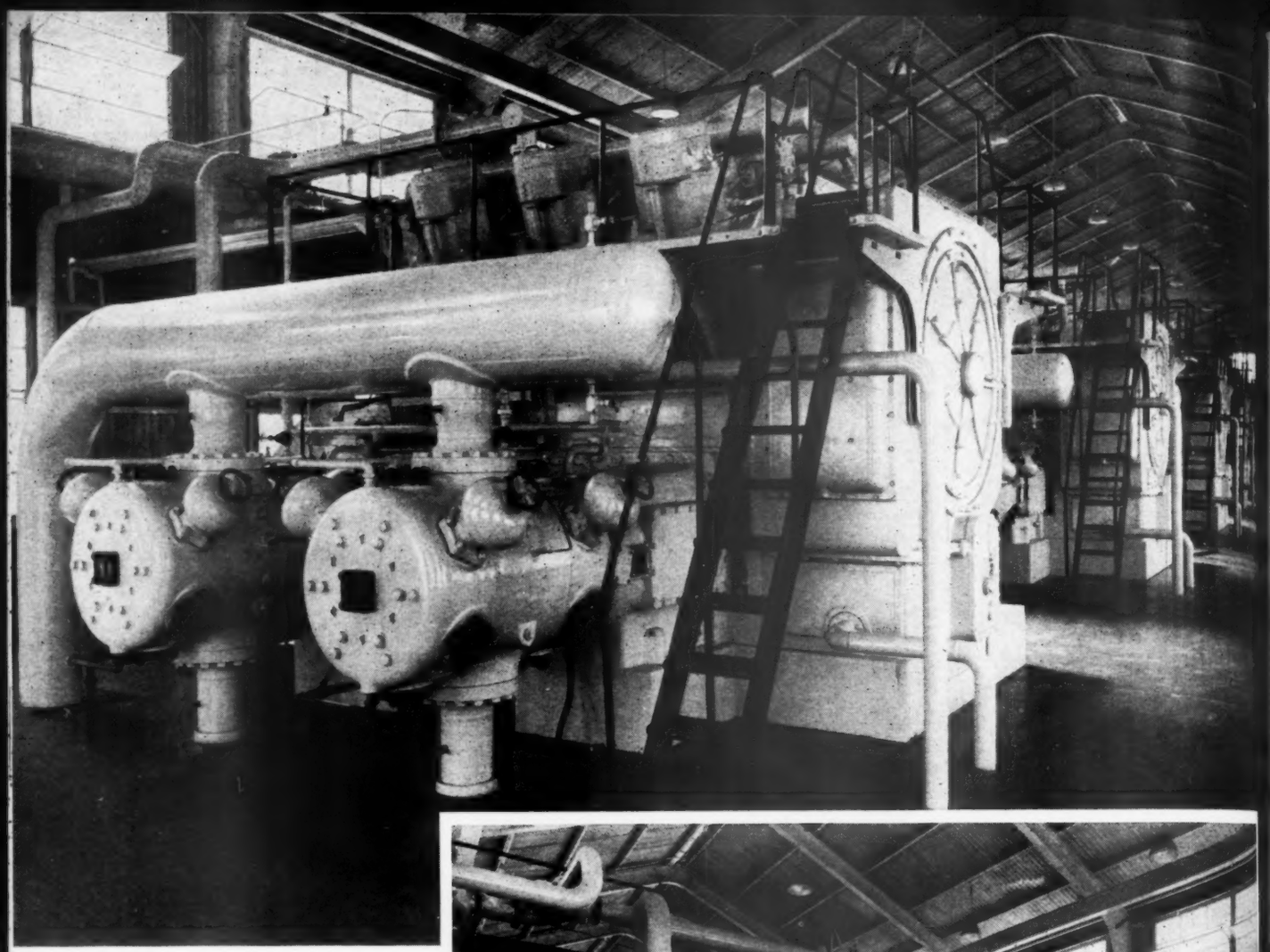
Italian refineries in 1953

	Capacity bbl/yr
A.P.I.	4,970,000
Aurora	149,000
Aquila	5,960,000
Condor	8,950,000
C.I.P.O.M.	49,600
Delle Piane	497,000
D.I.C.A.	995,000
Esso Standard	1,186,000
Garrone	1,490,000
Galletti	1,490,000
I.P.L.O.M.	298,000
I.L.S.E.A.	298,000
I.N.P.E.T.	11,950,000
I.C.I.P.	1,860,000
I.R.O.M.	11,100,000
I.R.C.O.	99,500
Lombarda Petroli	1,590,000
N.I.L.O.	447,000
Permolio	6,950,000
Petroli Italia	1,590,000
R.O.L.	497,000
R.A.S.I.O.M.	3,480,000
Siron Bianchi	588,000
S.A.R.P.O.M.	5,880,000
S.A.R.O.M.	3,820,000
Stanic	19,900,000
S.T.O.I.	995,000
Socony Vacuum	14,900,000
Sanquirico	596,000
S.P.I.	298,000
Volpato	248,000
	113,200,000

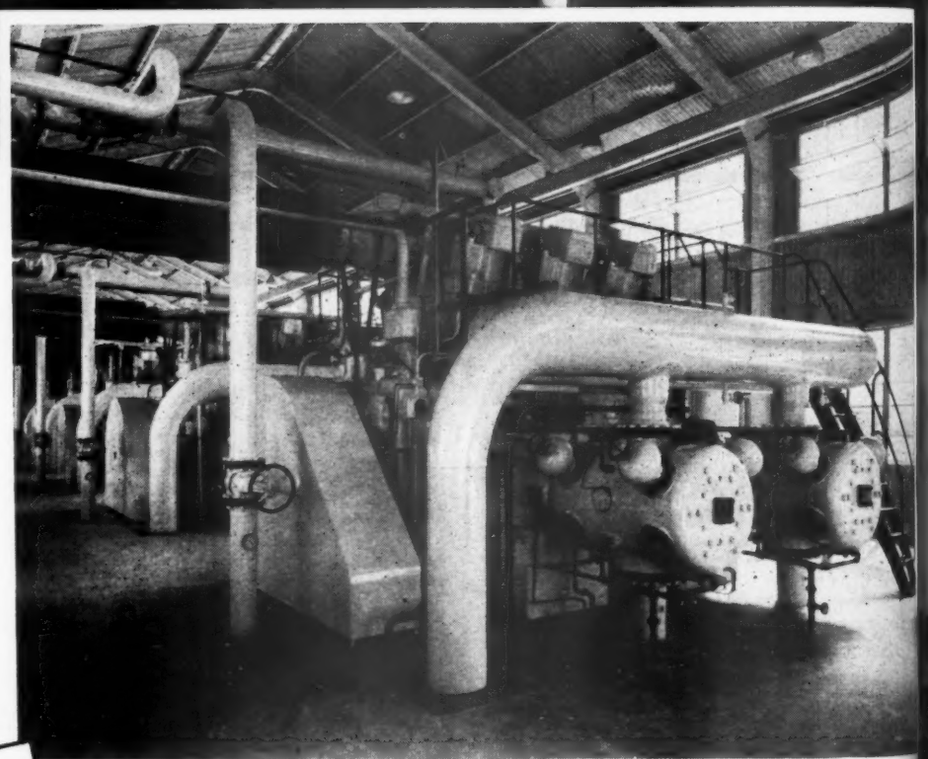
In 1954 the capacity of Italian refineries will be increased to 137,700,000 bbl per year.

The situation as it appears today causes great anxiety; on one side exportation difficulties, on the other a limited home consumption, due partly to the low individual income, but chiefly to the incidence of fiscal duties, which confer to Italy the little flattering record of the highest taxation on motoring fuels. As a matter of fact, in no other European country is there so tremendous a contrast between home consumption and capacity of refineries.

The problem could undoubtedly be solved if the eagerly sought petroleum could be discovered, which would mean both a beneficial increase of energy in the development of the Italian industry and a remarkable saving of money. Unfortunately this has not happened so far, nor can we know when it will; we therefore will keep wishing for substantial innovations in the present legislation of the petroliferous department which will allow both a greater home consumption and facilities of exportation in the countries of the Mediterranean basin. * * *



Line-up of Cooper-Bessemer GMW V-angles on United Gas Pipe Line Company's two largest compressor stations, the Edna No. 2 (top) and Refugio stations. Each station has eight 1500 hp GMW-6's totaling 12,000 horsepower per station. With separate jacket water pumps and magneto ignition systems, these modern V-angles can operate independently and are further equipped with automatic shutdown controls.



Main compressor building of the new 12,000 hp Cooper-Bessem powered Edna No. 2 station — part of the huge expansion th makes the United Gas system the world's largest.

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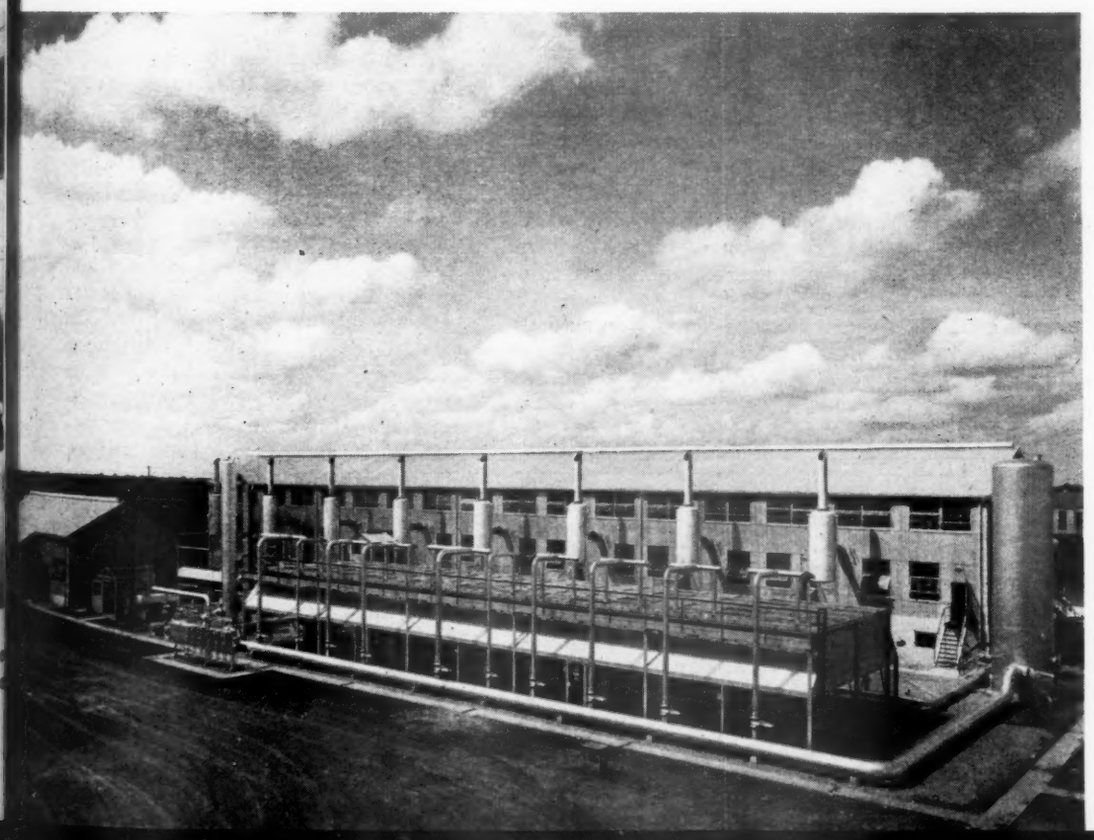
Throughout the South and throughout the world — wherever top performance is demanded — you will find smooth-working, compact Cooper-Bessemer units. If you are searching for efficient compressors offering increased profits and reduced operating costs, check with your nearest Cooper-Bessemer office.



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Incentives and the Individual†

RUSSELL J. VAN DAME

BELIEVE me, I am not an expert in the field of incentives. This is a subject that is highly controversial and far reaching in its implications. All that I can hope to do is to give you my impressions of the philosophy of incentive as I have observed it in practice at The Lincoln Electric Company. In that respect I shall do the best I can.

I feel that I am in the same position as the defendant who was convicted by a judge on a charge of arson on 10 separate counts of 99 years each, or a total of 990 years. "Your Honor," said the defendant, "that's gonna be mighty hard for me to do." "Well," replied, the Judge, "Just do the best you can!"

First of all, what is the meaning of the word "incentive"? Webster's dictionary defines it as "that which incites to action" or "a setting on fire". Now, there are many kinds of incentives. Parents used incentive to encourage their children to get better grades in school, radio and television stations fill the airways with "give away" programs ranging from free cooking recipes to trips to Hawaii as an incentive to buy their sponsor's products, shrewd politicians lavishly use patronage as an incentive to enlist the services of loyal workers and, I recently read in the newspaper that President Naguib of Egypt, in order to boost the literacy of his nation, has resorted to the use of incentives by promising the young men of Egypt a year's reduction in their military service for every 100 illiterates whom they teach to read and write.

Incentive As a Philosophy

Let us talk about incentive as a philosophy, as an effective tool to developing the latent, the unbelievable, the tremendous capabilities that lie within each of us as individuals. It is well known that the average person develops, throughout his lifetime, only a small percentage of his ultimate ability. Now, I realize that averages are not always infallible as is illustrated by the story of the statistician who was drowned when he tried to wade across a river with an average depth of 3½ ft. We cannot deny the fact, however, that all of us have been blessed by our Creator with ability and power which we have not begun to tap.

William James, the eminent phychologist, once said:

"The human individual lives actually far within his limits. He possesses powers of various sorts which he habitually fails to use. He energizes below his maximum and he behaves below his optimum." Let me draw a parallel to illustrate the truth of this statement. Forty-one years ago a giant ocean liner pulled out of the port of Liverpool, England and started on its maiden voyage, bound for New York. It was the largest and most majestic ship that had ever been built by man. It was called the "Titantic". Two days later word was flashed around the world that tragedy had struck the Titantic. This mighty ship had crashed into an iceberg in the North Atlantic and had sunk within two hours, over 1500 lives were lost. It was practically impossible for people to understand how an ordinary iceberg could be any match against the greatest and most powerful ship the world had ever known. What they had overlooked, however, was this seldom-known but indisputable fact — only 1/10 of an iceberg appears above the surface of the water — 9/10 of it is under water, dormant and silent.

I wonder if we cannot compare the ability of man with an iceberg. Isn't it true that 9/10 of it is under water, that only 1/10 of it is being utilized? The enormous power of the iceberg lies quietly below the surface of the water, while the untapped and dynamic power of the individual lies dormant, hidden in the subsconscious mind. And what is being done to lift this undeveloped 9/10 above the water? Only a mere fraction of what could be possible under the compelling influence of incentive.

It is true that during the past 50 years we have witnessed a rise in our standard of living that has been unequalled in any other period of history, but this spectacular progress has been due chiefly to the rapid development of machines. It is small wonder that this is known as the "Age of Machinery". The profound effect of mechanization on our daily lives is incalcuable but it has been vividly portrayed in a recent book called "The Big Change," written by Frederick Lewis Allen, the editor of Harper's Magazine. This is a fascinating and realistic story of the transformation of America from 1900 to 1950. As you read every chapter you are suddenly conscious of the dominating role played by mechanical equipment during this era of industrial advancement.

But, is it not a fact that throughout this same period only scant attention has been given by industry toward the development of the creative ability within the individual? His progress is limitless but we have done very little to arouse his capabilities. His latent genius represents potential power but it can be released by proper encouragement and intelligent treatment. The ability is undeniably there, only the spark to ignite it is missing.

Furthermore, there is an inherent

The Author

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Van Dame is a member of the Controllers Institute of America, and served as president of the Cleveland Control from 1952-53. Currently he is a member of the Institute's National Planning Committee.

†Delivered before the Akron Chapter, National Association of Cost Accountants, Akron, Ohio.

quality existing in every man which represents an inexhaustible source of power for the development of his latent capability. That quality is his overpowering desire to better himself. Man never stays fixed but constantly craves greatness. The aspiration to improve himself is alive and has been intensified by the industrial revolution.

He never has **everything** that he wants. There is no end to his **desires.** The industrial leader **must** recognize this irrefutable truth before he faces his next responsibility — that of making a man aware of his abilities. This is not an easy task. There is an inscription over the door of an ancient temple at Delphi that reads: "Know Thyself". It is believed to have been written more than 600 years before the birth of Christ. It is a bit of infinite wisdom that has been handed down through the years. In contrast to this, a very wise philosopher was once asked what he thought was the most difficult thing for a man to do. His answer was "To Know One's-self". There is, however, a spark that will ignite the ability of man. There is a means of proving to him, beyond the shadow of a doubt, that he possesses creative ideas far beyond his imagination. Where then is such a spark?

Well, it required a reverberating and thunderous crash from the prow of the mighty Titantic to explode the terrifying strength of the iceberg, and man, himself, will respond in like manner, when faced by crisis. Fortunately for us, however, a sudden emergency does not confront us too often so that we cannot depend solely on crisis to supply the fiery spark. No, we must look elsewhere for a more constant but less startling challenge and we will find it in the form of — incentive.

As I told you a few moments ago, we, at Lincoln Electric, have looked upon incentive in industry as a philosophy. We have regarded it primarily as a tool for the sole purpose of giving a man an opportunity to develop his ultimate potentiality. But, you ask, isn't the real purpose of incentive to create more production for greater profit? The answer is definitely—NO. Profit under the right kind of incentive is not a goal. It is merely a by-product. If incentive is adopted for the profit motive only, its chances for lasting achievement are extremely thin. As a matter of fact, the word "profit" today is associated with "greed" in many quarters. In terms of public acceptance "profit" is somewhat anemic after going through many years of sniping by its enemies. It has been said that "man cannot live by bread alone" and likewise industry should not exist for profit alone. Well, then, what is the reason for the existence of industry? The answer to this question constitutes the basis for our

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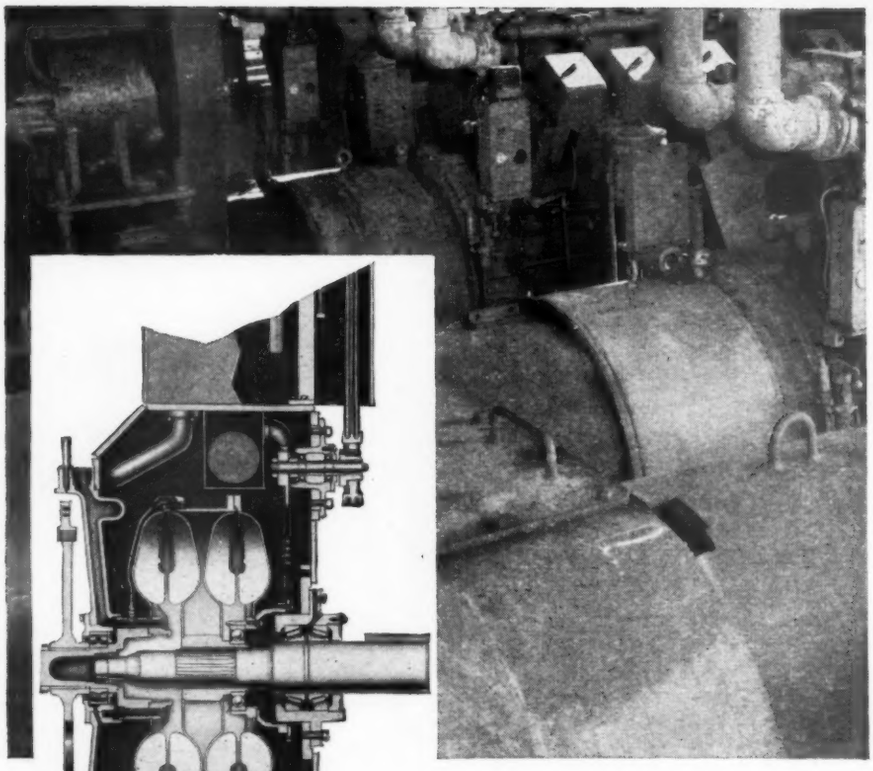

Davidson-owned Emsco J-1250 Drawworks—powered by three engines which also drive Gardner-Denver mud pumps—works through Twin Disc Model 27 HUD Disconnecting Fluid Power Take-Offs. New HUD (left) has integral cooling radiator, which can be provided for Model HUD's already working in field. Models 21 and 27 available, for engines from 100 to 600 hp.

Drills 318 days without downtime ...with Twin Disc Disconnecting Fluid Power Take-Offs

With an Emsco J-1250 Drawworks—powered by three engines driving through Twin Disc Model 27 HUD Disconnecting Fluid Power Take-Offs — Davidson Drilling Company has drilled 318 total days with no downtime from equipment failure. Also, the owner reports more ton-miles per drilling line.

By replacing mechanical connection with the smooth, flexible characteristics of fluid drive, the Twin Disc Model HUD's have eliminated such operational difficulties as chain-breakage, common with mechanical rigs. The HUD-equipped rig is eased into a load without strain or shock—heavy loads are pulled, even in sticky formation, without lugging or stalling the engines—and pipe-testing is made easier through better-held pump pressure. And with its positive disconnect feature, the Twin Disc HUD's eliminate need for engine compound clutches.

The owner's reaction? Davidson has already purchased another Emsco —equipped with Twin Disc HUD's. Write today for complete information on the *new* Twin Disc Disconnecting Fluid Power Take-Off . . . find out what its exclusive features will do on *your* drilling jobs.

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philosophy of incentive and here it is—we believe that the primary goal of any industry must be "to make a better product at a lower cost so that more people may enjoy it at a lower price". In other words, "more and more for less and less".

Our organization believes that the consumer is the ultimate boss. It is he who pays all the bills. He is the only reason why we are in business. Therefore, we believe that our entire efforts and energies should be directed toward serving him by producing a better product at a lower cost. That is the philosophy that can eliminate our costly and needless disputes between management and labor. That is the philosophy that can give all of us a better standard of living. That is the philosophy that can develop a stronger America.

The key that will unlock the door to such a Utopia in incentive and when properly applied — nothing becomes impossible. Let me tell you how it can be done. Two years ago our company built a new plant in Euclid, Ohio. There is a separate entry building through which everyone must pass in order to reach the manufacturing and office divisions. Affixed to the wall in bright aluminum letters measuring a foot in height are these words:

"THE ACTUAL IS LIMITED — THE POSSIBLE IS IMMENSE"

These words mean this—A machine is an "actual"—it was built to do a certain job. When it reaches a predetermined capacity it can go no further. But, when we consider the ability of man and his creative genius there is no such thing as a limit of capacity. If you need proof of this just think of the amazing and meteoric developments that have taken place during the past half century. Who can dare to say that anything is impossible when subjected to the mind of man? The recognition, therefore, of man's never ending potentiality is the first step in the adoption of an incentive philosophy.

Previously I mentioned that the primary reason for the existence of industry is to serve the consumer in the best way possible. This is an outlook that must be shared by each and every one throughout the entire organization. It is an "outlook" which has been unfortunately "overlooked" in far too many cases. In its place, however, we have created a condition that has led only to strife and chaos in our industrial life. It has resulted in a highly confused and disrupted economy. The danger of it has not been mitigated by the phrase ordinarily used to describe it, namely "Management-Labor-Relations". Picture, if you will, a table in triangular form. On one side of the table we find management, on another side we find labor. The third side is

unoccupied. The topic of their discussion is "Collective Bargaining". I doubt if there is anything collective about it and I'm quite sure that it is not a bargain for either side. It is more like a battle of mortal enemies. Each party usually enters the fray in a belligerent frame of mind and armed with selfish determination to win every point in his favor. The controversy usually ends with each one claiming victory which is something that the average man will never completely understand. Amid all the charges and counter-charges hurled back and forth by management and labor the conference table at which they are seated is continuously falling over. It often resembles the outcome of the meeting — a complete collapse of negotiations.

The reason, however, is quite apparent. While this is a triangular piece of furniture it is supported by only two legs, one marked management and the other marked labor. The third leg, representing Mr. John Q. Public, is missing. He is a non-combatant gladiator in this thing called "collective bargaining" but he is the one person who is most interested because he, the consumer, is the one who will have to pay the bill. He can only protest and he always loses. A new approach to management-labor relations is obviously needed, therefore, if we expect to develop a sound and peaceful economy. One more leg must be added to the triangular table to maintain its proper balance and the entire thinking of the two participants—Management and Labor — must be geared to a new philosophy. The question "What can I get out out of this for myself" must be supplanted by the question "What can we do to be of a greater service to the consumer?"

Team work and understanding are vital and they will develop automatically when there exists a common goal and a common desire to achieve that goal. A classic example of this philosophy is the outstanding record compiled by the Cleveland Browns football team. One of the chief reasons for their phenomenal success has been the intense desire of each and every player to win for the team. The thought of self glory has always been secondary. Paul Brown, the celebrated coach of that team made this comment in a recent speech: "A worker, like a football player, must have enthusiasm and determination, coupled with team work, good sportsmanship and the necessary amount of stamina to attain his goal. Discouragement must never enter their minds — only the constant drive and thought of "winning" will bring success to each."

This second concept of a common desire and a common goal, therefore, is a basic essential if the irresistible

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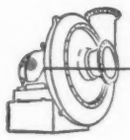

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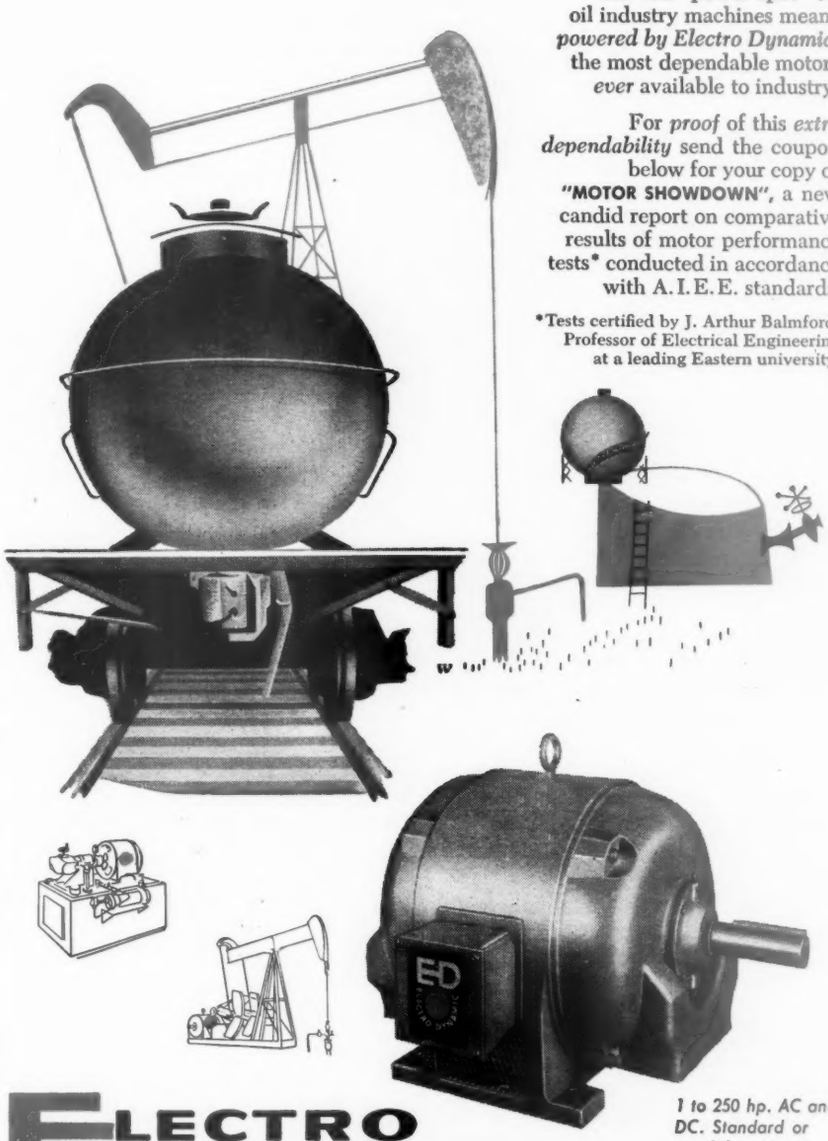

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force of incentive is to exert its influence.

A third requisite for a strong and effective incentive philosophy is the commanding presence of real leadership. When the question of installing an incentive system arises, 'suspicion' immediately raises its ugly head. Here then, is a challenge to leadership to gulf that bridge now existing between management and the worker. Too many incentive systems fail because they are sold to the worker instead of being adopted. There must be dynamic, vigorous leadership to enlist the loyal cooperation and genuine respect of the worker but—and this is vitally important—such leadership must be utterly sincere and unimpeachably honest.

Thus far, we have laid only the foundation for the construction of an effective system of incentive. We must now begin to lay the brickwork. And, it is at this point that I can begin to tell you of some of the methods which we are using at The Lincoln Electric Company to develop the latent capabilities of our people.

First of all, let's talk about money as an incentive. It is a very popular subject and I'm sure that all of us would like to get our hands on more of it. Money is a powerful incentive — there is no doubt about that. It enables a person to maintain himself and his family, to enjoy the comforts of life, to help others who are in need and to provide for the future. The practical importance of money cannot be minimized. Wealth must first of all be created. It is the sum total of natural resources plus tools, multiplied by ingenuity.

Babe Ruth did not receive an annual salary of $75,000 before he hit 60 home runs in one year. It was not until after he had achieved this extraordinary feat that he was paid such an amount. His ability to hit home runs at the right time enabled the New York Yankees to win a good many ball games which increased attendance and profits to the extent that a new and larger ball park had to be constructed to accommodate the crowds. It is no wonder that Yankee Stadium is known as the "park that Ruth built". In our industrial economy similar wealth is created by the development of man's skill and ingenuity. This progress can be described by the word "efficiency" and this, in turn, is reflected in lower costs. As these savings are passed along to the consumer, sales begin to rise and profit, the by-product — increases proportionately. Efficiency, therefore, is an inevitable goal. Everyone must concentrate all of his ability, all of his skill and all of his ingenuity on that one objective. No matter what kind of a job he may be doing at the present time he must constantly think of a more efficient way of doing it. He should never permit himself to be wholly and completely satisfied with his attainments. In other words, he must approach every responsibility with this positive attitude — "Everything I am doing on my job today is wrong. There is a better way of doing it tomorrow."

When an individual begins to analyze his job and then asks himself: "Is what I am doing absolutely necessary? Does it serve a real and specific purpose? How can it be done more economically? In what way can I become a more efficient worker? — he is actually directing those questions to his subconscious mind where there exists an inexhaustible storehouse of knowledge. I wonder how many of us realize the great power of the subconscious? Well, there was one man who did. He was born in the little town of Milan, Ohio about 60 miles from where we are meeting here tonight. Nicknamed "the Wizard" he became the greatest inventor the world has ever known. I am referring, of course, to Thomas Alva Edison who once made this profound statement: "All of my inventions and their answers are in my 'Inner Intelligence' ".

Let us remember the words of Rudyard Kipling when he wrote these lines:

"I have six honest serving men
They taught me all I knew
Their names are What and Why
and When
And How and Where and Who."

Yes, an inquiring mind, operating under incentive, sets in motion powerful forces that are augmented by imagination and vision and eventually produce the answer for which we are searching.

Efficiency can also be attained by setting a high standard. Individual ability will always develop far more rapidly when the objective appears to be over and above our present capacity. Ordinary effort does not break the record. But, when we solve the difficult and the impossible, it is then that we experience the real meaning of personal achievement. So, set your own sights high enough — in fact, set them on the world's record — and believe that you will be equal to the supreme test. If you miss — try again. Disraeli, one of England's greatest Prime Ministers, once said: "All of my successes have been built on my failures".

Since profit, therefore, is the eventual result of increased efficiency, it follows that it must be distributed as compensation on the basis of the relative contribution made by each individual toward the progress of the business. If the stimulus of incentive — in this case — money, reacts to a greater degree on certain individuals, resulting in more definite and concrete achievements, then those individuals must be rewarded accordingly. A question which arises at this point is: "How can you measure the relative contribution made by each and every individual?" It is not an easy question to answer. In our organization, however, we have developed a system called "Merit Rating" which we believe is a partial solution to this problem. Twice a year, everyone, with the exception of a top administrative group, is graded to determine the kind of a job which he has done during the previous six months. There are four factors considered:

1. **Job knowledge and skill.**
2. **Productivity or output.**
3. **Quality of productivity.**
4. **Attitude toward job and contribution to improvement.**

The average of the semi-yearly ratings is then applied to the individual's total yearly compensation in order to arrive at his share of the incentive payment. Those individuals who have done a particularly outstanding job are further rewarded by being presented with a Special Citation from the president of the company in recognition of their accomplishments.

A second form of incentive used to develop ability is a direct by-product of the merit rating system. The results of such a grading throw the spot-light on those individuals who might otherwise go undiscovered. This information is of inestimable value in the selection of personnel for promotion and the knowledge that it is being used for such a practical purpose has a highly stimulative effect on the individual, inspiring him to improve his efficiency.

Third, incentive philosophy recognizes the value of "man's pride in ownership". It acknowledges that the worker should not only share in the profits created by his ingenuity but that he should also be given the opportunity to plow back some of those earnings into the "team" of which he is a member. Consequently, we have established a plan of stock ownership that provides an excellent return for the shareholder and unites him in a harmonious bond with his fellow-workers. Men are made by responsibility and stock ownership gives them that responsibility.

Fourth, when problems arise, affecting the entire organization, they are more easily solved when they are fully understood. The job of keeping everyone informed, therefore, is of paramount importance. To accomplish this purpose an "Advisory Board" was created almost 40 years ago. The members of this group are elected by the workers and it serves as a board of directors to advise management and to keep all workers informed on company problems. This board serves as a connecting link welding together the entire organi-

zation as a team, thus emphasizing the time honored adage of "In union there is strength". And, in addition to this, the members, as representatives of other workers, assume a greater role of individual responsibility, become better workers and more respected citizens.

Earlier, I referred to the three participants in our triangular table discussion: The consumer-management-labor. How has each one of these fared under such a system?

Let's think about the consumer first of all. Our company manufactures two main products — electric welding machines and welding electrode. Twenty years ago the consumer paid $770 for a 300 amp Lincoln welding machine. Today, he can buy a 300 amp machine that is far superior in many ways and it will cost him only $510, a decrease of 34 per cent. Similarly, 100 lb of welding electrode would have cost him $12. Today it costs him only $11.50, a decrease of 4 per cent. And, do not overlook this fact — wholesale prices have skyrocketed by more than 100 per cent during that period. It has been conservatively estimated that Lincoln consumers have saved, over the past 20 years, more than $425,000,000.

Well, how about the other two participants: Management and labor? I shall regard them as one because, Gentlemen, a team is a single and inseparable unit, working together toward a common goal. The results have been two-fold—tangible and intangible. The tangible benefit, of course, has been a substantial rise in the individual's earning power which, of course, is in direct ratio to his contribution.

Recently, our company distributed its 20th consecutive annual bonus. One thousand two hundred and twenty-eight employees participated in an incentive payment which exceeded $5,000,000, an average of more than $4000 per person. This almost incredible amount is the reflection of the total combined efforts, skill and efficiency of all of the members of our industrial team. It is in no way an expression of paternalism. It is indicative of the results which may be attained when latent ability is aroused from its prolonged sleep by the powerful force of incentive administered by the capable hands of intelligent leadership.

Under the impact of incentive the individual has been inspired to reach for a goal which he never dreamed was possible, and — he has reached his objective. This has established confidence where none existed and has restored confidence where it was being lost. It has replaced his negative thinking with positive thinking. It has developed pride in himself and pride in his job. It has earned for him the respect of others and he experiences a feeling of inner satisfaction that he is a man among men. His life becomes richer through achievement and he is able to face the future with resolute confidence.

Let me read a paragraph from a letter written to the company president by the wife of a Lincoln employee:

"There is a feeling of security that permeates our home since we work at Lincoln Electric. I say "we" figuratively speaking. We don't feel like a cog in a machine but like an individual whose best points are being brought forth. The bonus has helped us to pay for our home, insure education for our daughter, and many other things. But, no money could ever buy a man's satisfaction in his job, or a wife's peacefulness when she knows that her husband is at last getting a fair chance."

This, then, is the lofty purpose of incentive — to prove that all things are possible through the creative and infinite ability of man and the greatest Book ever written affirms this truth by these words:

"For thou has made him a little lower than the angels and has crowned him with glory and honor. Thou madest him to have dominion over the works of thy hands; thou has put all things under his feet." * * *

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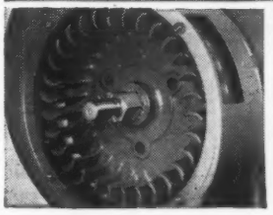
Performance Features



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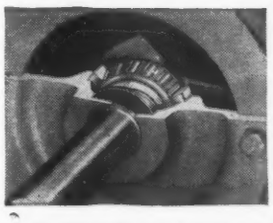
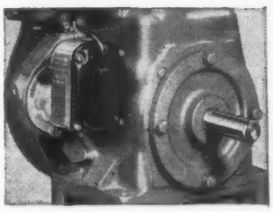
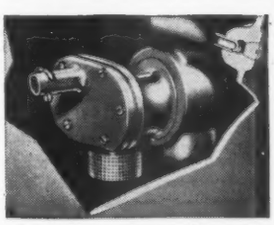
No machine is any better than the Power that drives it. And efficient cooling, under all operating conditions, is one of the first essentials to dependable power! A large capacity fan, cast in the flywheel of every Wisconsin Engine, provides trouble-free cooling, even in the most extreme temperatures.



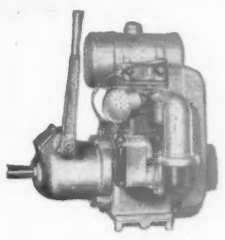
TAPERED ROLLER BEARINGS AT BOTH ENDS OF CRANKSHAFT . . .
These self-cleaning, file-hard bearings take up all load thrusts, permitting the use of either chain-, belt- or gear-drive direct from the extended crankshaft, without fear of damaging main or connecting rod bearings. This does away with the need for an outboard bearing.



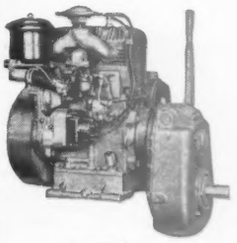
HIGH TENSION, ROTARY TYPE OUTSIDE MAGNETO . . .
Positive gear drive direct from camshaft assures steady, uniform ignition at all times. The complete unit is conveniently mounted on the OUTSIDE of the engine for easy accessibility. Weather-sealed against moisture and dust. Equipped with Impulse Coupling for quicker, easier starting at all seasons.



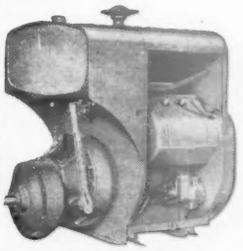
POSITIVE, PUMP-CIRCULATED LUBRICATION . . .
All single cylinder models (with exception of Model AEN) have pump-circulated level-splash system. Model AEN and multi-cylinder models pump an individual oil stream to each connecting rod. Other parts are lubricated by oil spray, assuring complete and thorough lubrication for smooth-running and long engine life.



Single Cylinder
6 to 9 hp.



2-cylinder
7 to 15 hp.



4-cylinder V-type
15 to 36 hp.

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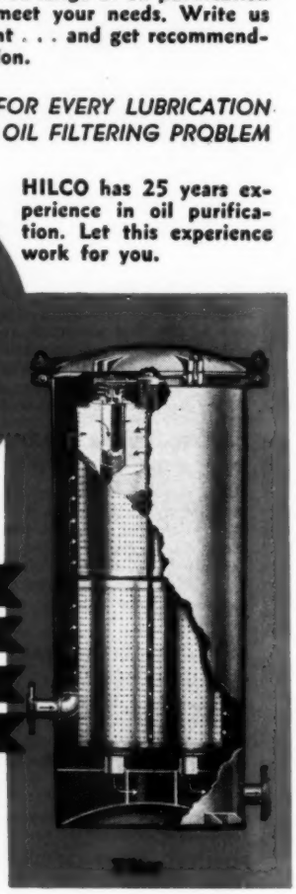

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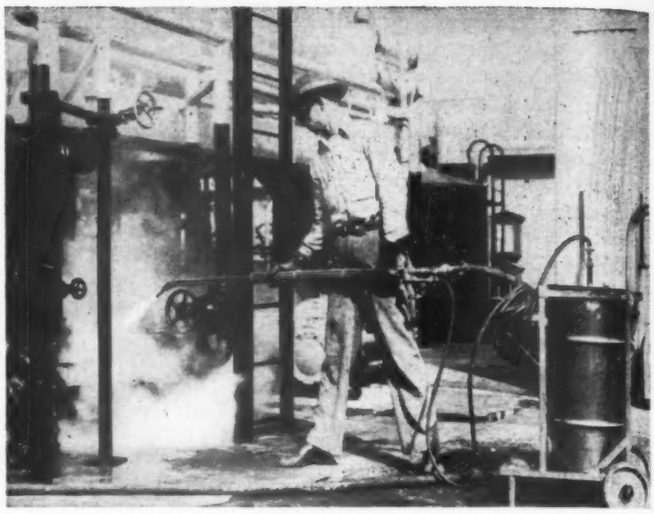

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Refinery finds Oakite Detergent applied with Oakite Steam Gun makes short work of cleaning prior to repainting.

THE cleaning problem this California refinery had was simple enough. It was one of removing all dirt, grease and muck from tanks, pumps and similar equipment. But actually doing the job was not so simple. It meant tedious scraping, wirebrushing, wiping by a sizable crew. It involved struggling with hard-to-get-at surfaces. Did the Oakite Man have a better answer?

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Petroleum Hasn't Time for a Recession†

JOHN BOATWRIGHT*

THE air and the press have been so full of business forecasts that I have grown weary of them and also frequently disgusted. You can today get business forecasts at the rate of a dime a dozen. Politicians, labor leaders, farm leaders, business leaders, foreigners, economists, statisticians, and even authorities in the physical sciences and ministers are joining in the parade. The digest of my views on this subject can be summarized both pro and con in six brief points which I shall present and then we can turn to a topic of real interest to me—petroleum and South Dakota. On the bright side of business outlook, I list four prominent factors:

1. Population Growth

The population of this country has increased by almost 2,700,000 per year since the war. This increase represents an annual expansion of the consuming market approximately equal to the total population of South Dakota, North Dakota, Montana, Idaho, and Wyoming combined.

Think of the expansion of the food and clothing market, the thousands of new homes, schools, churches, hospitals, automobiles, and so on, ad infinitum, that must be made available. There is no more vivid evidence of the confidence and faith in the future than this.

2. Technological Progress

Technological progress raises the standard of living at an astonishing rate, creating ever greater and newer markets. Each new industry creates other industries and increases the productivity of the economy. Visualize for a moment the automobile, the tractor, the airplane, the oil heater, the radio of the earlier decades of your life.

Now think of the new industries of more recent years, such as the television, nuclear energy, the petrochemical industry, the whole field of synthetics, the progress in the biological sciences, and the wonder drugs. Our achievements in these fields are the fruits of the tremendous research program of industry, government, and universities.

This nation invested approximately three and three-quarter billion dollars in technical research in 1952 according to the Research and Development Board of the Department of Defense. These expenditures have increased at the average rate of $350 million per year from 1946 to 1952 and every indication points to continued expansion. Tremendous new industries have grown out of this effort and even greater ones are in the offing.

3. Business Reassured

The improved business environment must be mentioned as the next bright spot on our horizon. It is asserted by some that capital facilities are overbuilt. These alarmists need to re-examine their data in the light of the increased population, variations in the purchasing power of the dollar, rapid obsolescence of productive equipment, and other changes in our economy that have rendered previous benchmarks of capacity calculations inappropriate. When these factors are recognized, our plant capacity seems no more than adequate for our growing needs.

The restoration of business confidence is based upon elimination of waste in government, proposed incentives to stimulate new capital expenditures through more liberal depreciation policies, partial relief from the double taxation of dividends, and the ability to write off research and development expense. Of particular interest in South Dakota is the proposal to allow full deduction of soil and water conservation expenses.

These steps will help restore business confidence and open up new capital flows into increased plant expansion.

4. War Industries

A state of striving for military preparedness appears to be our inevitable lot for years to come. This means that we must be ever ready with the required tools of defense. Therefore, a significant percentage of the nation's total industrial activity must be devoted to war industries. I sincerely hope that the military tools may never have to be called into active use. I am convinced that the best way not to have to use such tools is to possess a formidable array of them.

Perhaps you wonder why I classified this part of our economy as one of the "bright spots". Do not misinterpret me, this is a bright spot only as it contributes to the general level of business activity and national security.

Now may I summarize these broad points concerning the long range business outlook. First, we are adding a consuming market each year equal to the population of five states. Second, new businesses are being born daily of vast unknown proportions. Third, business faces a healthier environment for growth and has the liquid assets with which to achieve a sound expansion. Fourth, whether we like it or not, much of our material strength must go into defense activities for years to come.

On the other side of the picture, I see only two significant dark clouds.

1. Threat of Dictator Nations

I am unable to find in history any illustrations of totalitarian governments built on a basis of ruthless conquest coexisting without conflict with an otherwise free world. I can find many illustrations of the opposite. Hence, I cannot accept the philosophy of some that both the free world and the Communistic world can "live together". The history of the future will prove the impossibility of such peaceful co-existence.

It is my prayer that our preparedness may be so massive that it will impress the leaders of the other world and they will realize that to attack would be suicide.

Next it is my hope that the yoke on oppressed peoples will be thrown off from within. We have seen that a to-

†An address before the Rotary Club, Huron, South Dakota, March 31, 1954.

*General manager, Distribution Economics Department, Standard Oil Company (Indiana).

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The floor was 8 to 10 inches of concrete, reinforced with ¼ inch steel rod. It was broken up with air tools, then loaded into a dump truck by the digger. Manual loading would have been difficult because of the reinforcing rods, but these presented no problem when loaded mechanically.

Digging and loading took less than four hours, in spite of the limited maneuvering area. Estimated time for hand labor: Three men working about 2½ days!

If you now excavate by hand, or if your heavier power equipment cannot work in tight spots, you'll profit with a Sherman Power Digger. It's compact, flexible, fast, easy to operate. It costs little to buy, less to maintain, quickly pays for itself. For the whole story, write today for Bulletin No. S13.

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talitarian government built on violence cannot establish a line of descent. Each change of leaders inevitably means another period of blood letting.

The other cloud I visualize is most disturbing. I shall just mention it without elaboration. Too many Americans have lost their individual zeal and zest for work. This must be recaptured if our historically unparalleled growth is to continue.

No Receding Activity in Petroleum

Now I am through with general business conditions. I want now to turn my attention to an industry that isn't "recession-minded" — Petroleum. We do not have the time to entertain thoughts of receding activity. We barely have the time to do the building that is required for the future.

During 1954, the oil industry must find 148 billion additional gallons of crude oil. That is such a big number that it is difficult to visualize. Let's first reduce it to quantity per day. We find it is equal to 405 million gallons each day of the year. I still can't visualize it, so let's put it in tank cars and make a train out of them. Now I can bring these numbers within the scope of my imagination. The train would reach from Huron, South Dakota, to Des Moines, Iowa. That is a lot of oil to find every day concealed in porous rock at various depths down to three miles below the earth's surface. Therefore, the industry will have to hunt just as intensively and on an even greater scale than in the past to fill our needs.

Core drillers, surface geologists, seismic crews, engineers, supply houses, and laborers in the exploration of oil may logically look forward to a more intense and active year than we had in 1953.

Montana, Wyoming, North Dakota, and South Dakota will see increased exploration and drilling activity for many years to come. Actually the industry has but scratched the surface of what is believed to be the potential productive capacity of this area. Recently, South Dakota joined the ranks of producing states with a well near Buffalo in Harding County. The tests of this well are sufficiently encouraging that a second is now being drilled about one-half a mile from the discovery location.

Although this is the first producing well in South Dakota, drilling activity has been intense over the past few years. Since 1950, the oil industry has spent more than $30,000,000 on exploration and drilling in South Dakota and this well is the first evidence that any return will be forthcoming from that expenditure. Stanolind Oil and Gas is now drilling a test well two miles west of Karinen, Harding County.

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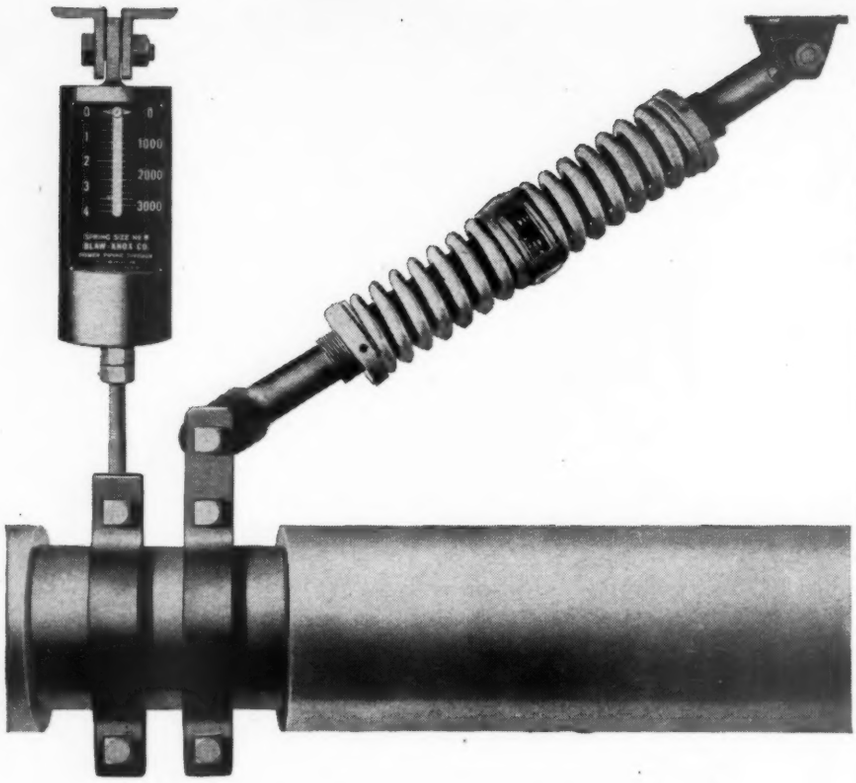


complete hanger units cut your field erection costs

One sure way to cut your field erection costs is to use Blaw-Knox hangers and eliminators. Each is a complete packaged unit, ready to install. No expensive cutting, threading and assembling on the job. And you'll also save on engineering and specifying time.

Each Blaw-Knox functional spring hanger, rigid hanger assembly, overhead roller assembly, and vibration eliminator is designed for a specific purpose. Constructed to conform with the "code for pressure piping." Available in types and sizes to meet varying conditions.

Any time you'd like some help, our experienced engineers are available to both design and make recommendations for your hanger requirements. Send for your copy of Bulletin No. 54 to get full information.

BLAW-KNOX COMPANY, Power Piping and Sprinkler Division, Pittsburgh 33, Pa.

BLAW-KNOX

PIPE HANGERS

Complete line of functional spring hangers • rigid hanger assemblies • overhead roller assemblies • supports • vibration eliminators . . . plus complete prefabricated power piping systems for all pressures and temperatures.

Exploratory activity, which must precede the actual drilling, is also moving ahead at a rapid pace in South Dakota. There were 7 seismic crews reported as of January 1, 1954. Leasing activity further indicates the interest of the industry in this area. Over 7,000,000 acres are under lease in South Dakota. It is understandable that the Federal Reserve Bank of Minneapolis should conclude that: "There is every reason to believe that the oil development, in its third successful year, will become an important factor . . . a leading source of revenue for many Montana and Dakota communities."

Exploratory and drilling activity is proceeding at rapid pace in the states of North Dakota, Wyoming, and Montana. To the north oil has been found near Fryberg, which is only 65 miles from the South Dakota border. To the west, especially in Weston County, Wyoming, there were 237 tests drilled in 1953, of which 210 met with some measure of success. At the height of drilling last fall, almost 50 drilling rigs were working in the Clareton area. Tremendous exploratory activity characterizes the Williston Basin with approximately 85 seismic crews in this region in the Dakotas, Montana, and Wyoming as of January 1, 1954. This activity alone represents an expenditure of about $30,000,000 per year.

Pipe Line Building

Crude oil in the ground has no value. It must be brought to the surface and transported to refineries for conversion into products that consumers want. Transportation by truck or tank car has been found too expensive to establish large operations. To compete with crude produced in other regions, new discoveries must be built up to volumes that assure the people who finance the building of pipe lines that there will be plenty of oil at the source as well as buyers at the other end. West Texas was held back for years until large pipe lines were available. Canadian production for years has been limited by lack of sufficient transportation capacity, but now appears to be approaching a better balance.

There has been quite a bulge of pipe line building since 1950. The Platte Pipe Line, the Rancho, the Sinclair Line to Chicago, the Lakehead from Superior, Wisconsin to Sarnia, and many others too numerous to mention have been built. Large natural gas transmission lines have shown an even greater rate of growth. This has meant pouring hundreds of millions of dollars into additional transportation systems. Certainly it would seem that such activity would tend to ease off. But will it?

There are new horizons coming into proved producing areas. They are de-

manding an outlet and the privilege of competing for the market. Old markets are expanding and new markets have yet to be reached by lower cost energy supplies. The economics of many new pipe line projects are being examined. New lines are on the drawing boards. Pipe line delivery of Williston Basin crude and products is becoming increasingly important.

Several projects are being reviewed at the present time although it is too early to determine which are likely to be built. New lines and expansion of present systems will continue to be made during 1954 and for years to come. Suffice it to say at this point that total capital outlay for petroleum and natural gas pipe line construction in this country and Canada in 1954 will probably equal the average expenditures during the past three years.

Refineries have been built until today the refinery phase of our industry offers a surplus productive capacity of approximately 1,000,000 bbl per day. This is a cushion for security that must be maintained. But the excess capacity is not the real story as I see it. The significant fact is that building continues apace to supply you and our armed forces with better quality products.

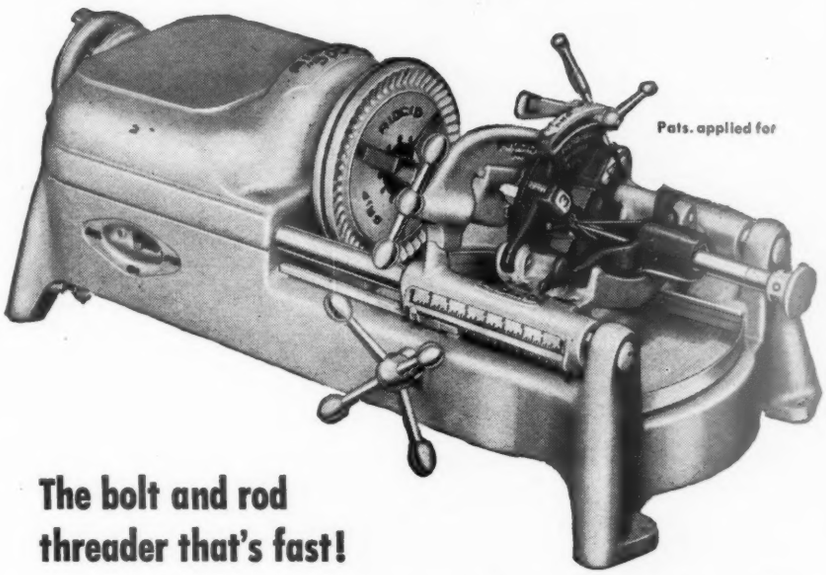
Is it any wonder that Dr. Gustav Egloff, research director for Universal Oil Products Company, estimated that the higher octane gasolines now made available at tremendous capital outlay save the American consumer one billion dollars per annum in increased power delivered. Or again, we could look at the motor oils that perform their responsibilities equally well in temperature ranges from 40 degrees below zero to over 100 degrees above.

Again we might look at the petrochemical industry making products for more food production, pest elimination, fungicides, better clothes and so on through a long list of contributions to higher standards of living. Tremendous toluene-producing plants insure ready availability of explosives for protection. Numerous alkylation plants insure that our defense may be adequately airborne wherever the enemy chooses to draw the line.

Building of refineries will continue at an accelerated pace. It will continue because we must be prepared to meet a larger and larger market with better and better products. Certainly the Standard Oil Company has provided tangible proof of its confidence in the future of the Williston Basin area. By the end of 1954, we will have completed facilities stretching from well to consumers with our crude pipe line from Tioga, a refinery at Mandan, and a products pipe line to Moorhead. These facilities are in addition to our activity in exploratory surveys, leases,

For Fast Bolt Threading
... it's the New 500A
RIDGID
with new "SPEED-GRIP" CHUCK

New principle ... not just another hammer chuck!



The bolt and rod threader that's fast!

Capacity ¼" to 2" bolts — pipe, too, ⅛" to 2"

You've got to see it and try it to believe it! Only 2 quick-opening die heads—small head for ¼" to 1" bolts, large head for 1¼" to 2" NC, to 1½" NF—to 2½" in 8N, 12N and 16N . . . easy die change, right or left hand threads, easy adjustment to over or under size. Special dies on request. This 500A threads any length bar to 2½" diam., makes studs with RIDGID Nipple Chuck, cuts off 5/16" to 1" rod. Independent operation of tools. Lots of power. New Speed-Grip Chuck guaranteed to hold rod or pipe securely *forward* or *reverse*—motor action makes it tighter. See it, buy it at your Supply House.

THE RIDGE TOOL COMPANY • ELYRIA, OHIO, U.S.A.

RIDGID
Work-Saver Pipe Tools

test drilling, and production mentioned earlier.

Confident of Future

As you may have gathered from this recital of investment accomplishments and plans, the Standard Oil Company has no recession complex. My company has just announced that it plans to spend one-half billion dollars on expansion and upgrading of its facilities within the next two years. No more tangible proof of confidence in the present strength and hope for the future can be offered by industry.

Certainly this confidence in the future is not the exclusive property of the Standard Oil Company, or even the petroleum industry. However, I am particularly proud of the part the petroleum industry has played in the unprecedented prosperity of this country. The Chase National Bank estimates that since 1946 the petroleum industry has invested over $23 billion in facilities. Last year alone, the industry spent a record $4.2 billion on new facilities and improvements, exceeding the previous record of $3.8 billion in 1952. I expect 1954 expenditures to at least equal and perhaps exceed $4¼ billion.

I have left the marketing part of our discussion to the last. Here I touch on every part of your lives — a part of lives in every corner of the continent. Petroleum is everywhere.

During the post-war period, the needs for increased production, transportation and refining capacity were so great that the industry generally "got along with" its existing marketing facilities. Demand is still growing and competition is forcing greater recognition of the needs of modern marketing. It was no surprise to me that the McGraw-Hill poll estimated petroleum expenditures for marketing facilities in 1954 will be increased by 11 per cent over 1953. How much and how many new and improved outlets may be provided cannot be estimated. I believe it is safe to say, however, that expenditures will increase substantially.

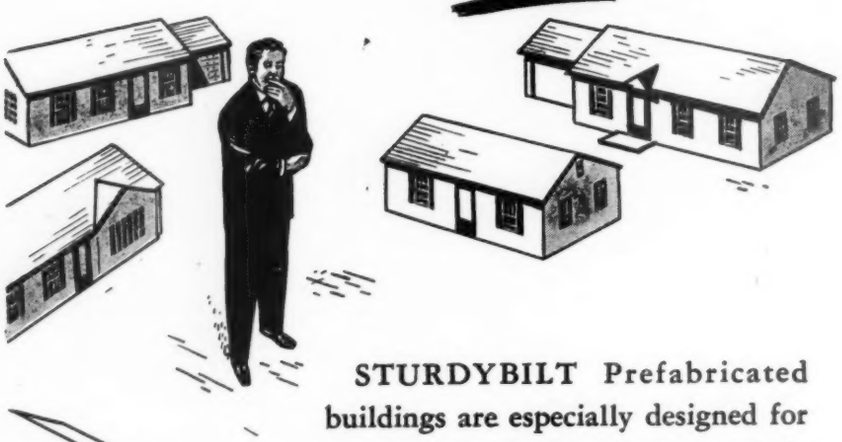
Looking at the whole petroleum picture, therefore, what do we see? We see an industry still building rapidly and without pause for increased capacity and quality improvement. How important is this?

It is difficult to select one industry out of the total economy and give its unique importance. I could remind you that oil and natural gas supply 64 per cent of the energy needs of the nation. Or I could mention that capital requirements of the industry represent approximately 14 per cent of all industry capital outlay. I could mention payrolls because the industry employs something upward to 1.2 million people directly associated with supplying your needs. Certainly petroleum constitutes an important segment of the economy.

It will go forward. It will be joined by the entire petrochemical industry and the chemical industry generally. The nuclear fission industry is but on the threshold of currently unimaginable expansion. The electrical energy demands of this country have been growing by leaps and bounds, necessitating tremendous increases in capital outlay for generating plants and distributive facilities. The airplane, particularly jet propulsion type, will call for a phenomenal expansion of airplane building and operation. The television market is expanding rapidly with the installation of new stations and will continue to grow. These are clearly growth potentialities. We cannot catalogue all growth type industries but we must keep in mind that each year we must feed, clothe and educate an additional 2,700,000 people. This is a basic growth that all industry and farming must recognize.

For these reasons, the oil industry is building to the future with the same conviction and optimism as millions of fathers and mothers who are bringing into existence approximately 3,700,000 babies per year. What do you say — let's all forget about recession and keep on building! * * *

CHOOSE THE FIELD HOUSING DESIGNED FOR *YOU...*



STURDYBILT Prefabricated buildings are especially designed for the oil fields. That's why they include such features as ECONOMY . . . PORTABILITY . . . DEMOUNTABILITY plus weather-tight construction and standard designs to suit any housing need.

MANUFACTURERS OF SPECIAL MILLWORK: DISTRIBUTORS OF JOHNS-MANVILLE BUILDING MATERIAL; CURTIS WOODWORK

Choose your housing as carefully as you do your equipment. Be sure to get housing that is especially designed for the oil fields.

■ WRITE FOR INFORMATION

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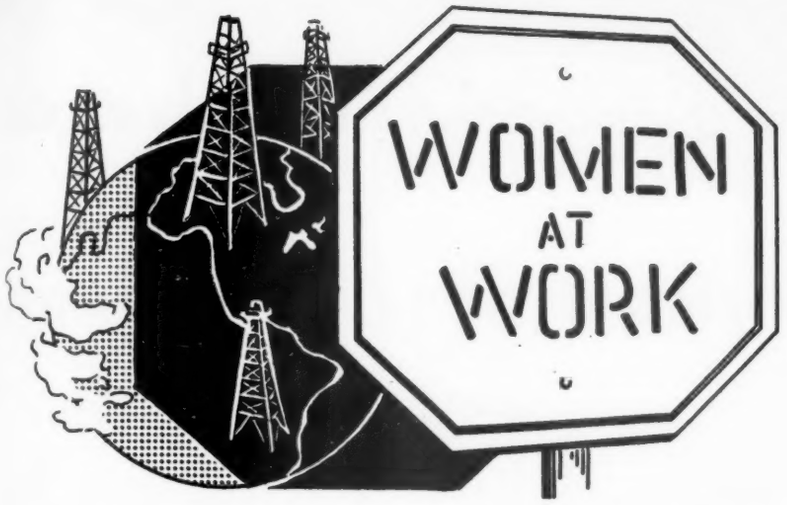
STURDYBILT HOUSES COMPLY WITH COMMERCIAL STANDARD CS125 OF THE NATIONAL BUREAU OF STANDARDS FOR PREFABRICATED HOMES



Oil Scout Freyou

Beatrice Freyou is a well-known name in Louisiana oil circles. As head of the Crude Oil Scouting Department of Esso Standard Company of Louisiana, she keeps track of 700,000 barrels of oil daily in all sections of the state. She has been handling this gigantic task since shortly after she came to work in Esso's Baton Rouge office in 1947.

The first woman oil scout in the South and one of the first three women members of the National Oil Scouts and Landsmen's Association, Bea is concerned with keeping tab on every activity of competition in the oil business. It is her duty to compile cross-section data on all production in Louisiana and turn it over to the company's crude oil-purchasing department. In addition, she prepares a monthly report of oil findings for distribution to all major companies as a courtesy of Esso.

Bea remembers vividly one experience of her early oil career. As a new employee of the Department of Conservation in Houma it was her responsibility to take all incoming calls and turn them over to the proper recipient. Early one morning she answered the phone, took a message that a well had blown out near the city. She wasn't particularly impressed and might have forgotten the message if one of the engineers hadn't sauntered in and asked if there'd been any calls.

"Oh yes," Bea said, "Some company called in and said they had a blow-out north of town."

"WHAT DID YOU SAY?" shouted the engineer. He invited her to go with him to the scene.

"The experience is one I'll never forget," adds Bea.

Mrs. Freyou is a member of the Desk and Derrick Club, Region III director for 1954 and was Baton Rouge's nominee for Oil Woman of the Year in 1953. She began scouting work in 1943 for Carter Oil Company and joined Esso Standard in 1947. When she can manage a few moments from her duties, Bea gardens, works on her scrapbooks and visits with her nieces and nephews.

"My two nieces," she adds, "are oil people. Their home is in the midst of a company gasoline plant so rigs, oil trucks, boilers are everyday scenes to them."

Beatrice Freyou helps a former apprentice, Clara Holly.

Pipe Line Expert

Pin-pointing **Elizabeth Van Kuyk** is like explaining Einstein's theory of relativity; it can't be done in one easy lesson. Elizabeth has almost as many names as she has personalities as she has activities. Christened Elizabeth Jeanne, she signs her correspondence "E. J.", prefers her nickname, "Betty" and often answers to "Van." At Socony-Vacuum Oil Company in New York she is assistant manager of the pipe line right-of-way division, a title that carriers with it so many responsibilities and duties that it takes two pages — typewritten and single-spaced! — just to list the major ones.

Pipe line specialist Van Kuyk.

In addition, Betty is president of the 420-member Desk and Derrick Club of New York City.

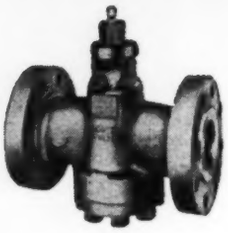
Accomplishing the unusual is nothing new to Van. Her musical talents were so superior that several teachers urged her to make music a career. In 1934 she went to work in the law department of Socony-Vacuum. A year later, when the company acquired South American interests, the young musician-stenographer enrolled in a Spanish course. Two years and 40 Spanish lessons later she volunteered to translate the Colombian and Venezuelan journals for her company.

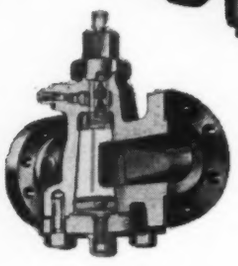
In 1943 Miss Van Kuyk was given leave from S-V, and spent the next three years in secret and dangerous missions as a plain-clothes cloak-and-dagger girl in Europe.

The clerical duties assigned back at Socony-Vacuum seemed tame to Betty after her war assignments, so again she asked for more work. She has handled practically every assignment in the pipe line right-of-way business — planning, managing, negotiating, drafting, and checking. From 1946 to 1948 she spent most of her time in the field where she has successfully supervised as many as 15 right-of-way men. As soon as she got back home she enrolled at New York City University in law. Now she spends most of her time at the home office in New York, but goes out often to search records and clear titles.

A native New Yorker, Betty enjoys the theatre, opera, and the concert stage. Her reading runs from light books to the classics. She travels as often as her job can spare her.

Life will never bore Betty Van Kuyk. She'll just look around for a dozen other worthwhile duties to spill her ability and enthusiasm into.

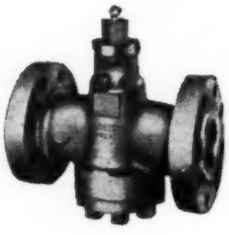
THIS  is a remarkable valve, as

 . . Lubricant goes in through

grooves in the plug . . . . and body

three things—it lubricates the seat . . .

acts as a hydraulic jack . . . . to keep the

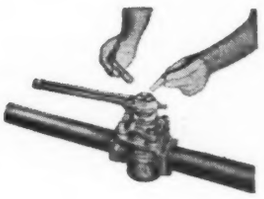
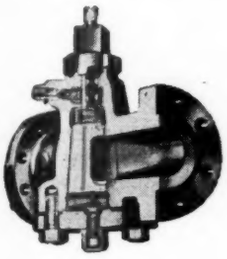
this valve  is safer, because it can

because lubricant stops seepage

because, by eliminating friction

most valves. What kind of valve is it?

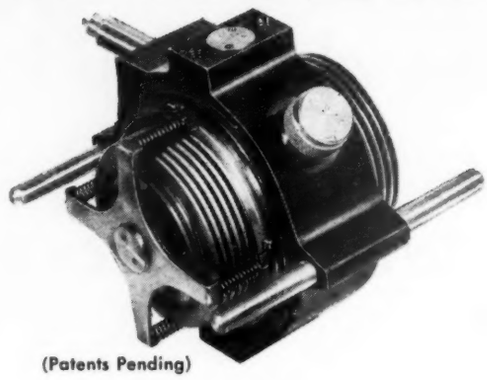
by **ROCKWELL** Manufacturing Company,

you will quickly see when you look inside the stem  and is forced through  . . In service, this lubricant does —it seals off the seating area . . . and it plug in position to turn easily. Consequently always be operated in an emergency, and, before it starts. It's also more economical and abrasion, lasts much longer than Naturally, it's **ROCKWELL-NORDSTROM,** Pittsburgh 8, Pennsylvania.

Canadian Licensee:
Peacock Brothers Limited

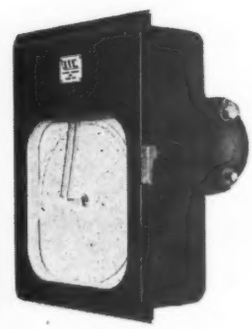
flow meters

WITH FEATURES
THAT MAKE
A REAL
DIFFERENCE
IN SERVICE



(Patents Pending)

1. Greater power, longer-calibrated travel for assured accuracy.
2. One-piece seamless, type 316 stainless steel bellows. No pitting, no welds, longer life. (Monel bellows can be furnished for special services.)
3. An exclusive I.I.C. development, the patented free floating Non-Freezing Instrument Bearing, makes possible a new era in flow meter accuracy.
4. Differential obtained from actual displacement of fluid and not from stem movement.
5. Over-range protection to housing rating.
6. Pulsation may be dampened in service without special tools.
7. Complete compensation for wide range of ambient temperatures.
8. All standard ranges available: 0-10" H_2O to 0-300" H_2O.
9. Working pressures up to 5,000 psi.
10. No precise leveling required.
11. Self-draining. No seal pots required.



Model 802 Recorder
(Patents Pending)
IIC Model 802 Recording Flow Meter is actuated by Model 700 Meter Unit.
Simple installation. Built by experienced instrument men from a simple design, engineered for rugged duty.

Model 800 Indicator
(Patents Pending)
IIC Model 800 Indicator is actuated by Model 700 Meter Unit, is calibrated in same manner as Model 802 Recorder.

Model 800-6 Indicator
(Patents Pending)
IIC Model 800-6 Indicator is actuated by Model 700 Meter Unit. Standard 6" dials available in uniform, square root, as well as other special ranges.

Model 700 Meter Unit
(Patents Pending)
The new standard of quality for metering devices, the Model 700 Meter Unit is used by other instrument manufacturers to actuate their own differential pressure recorders, indicators, controllers and transmitters.

Write for Bulletin 56-B

INDUSTRIAL INSTRUMENT CORP.

BOX 1909 ODESSA, TEXAS

Gas Engineer

From school teacher to gas engineer may seem like a far jump to most people, but **Marie Kent Blundy** made the leap back in 1926 and she's still using the knowledge gained in her first profession to advantage in her second.

Mrs. Blundy is chief clerk of the producing division Gas Measurement Department of The Pure Oil Company in Chicago. As a gas engineer, Marie is something of an oddity in a male-dominated field. She has been with Pure through the days of the "extension table" to the present day of chart computing, integration and punch card accounting. She is looking forward to electronic computation.

"Marie," say her employers, "has avidly absorbed each new concept and today is one of the most completely informed flow measurement engineers in the industry."

Something of a pioneer, Marie has been quick to strike out on her own. Mathematics and thermodynamics, shunned by most women, come to Marie Blundy like her ABC's.

The Pure Oil Company was a newcomer to Chicago in 1926 when Marie, a pretty little Irish school teacher, first came seeking employment. She was hired, bringing with her a background in personality management that has been a mainstay through the 27 years she has had women under her supervision. Next to people, which is Marie's chief interest, comes traveling. She follows devotedly the domestic and business careers of the many ladies who have, at one time and another, worked with her at Pure.

Succeeds in a man's job.

Equally as adept with a food formula as she is with a gas formula, Marie is a whiz at the cook stove where her specialties are steak and potatoes, corned beef and cabbage—with no frills.

PERSONALS

D. L. Campbell

B. C. Belden

R. S. Piroomov

F. W. Schumacher

W. E. Helmick, senior exploitation engineer, Shell Oil Company will retire July 1 after 32 years in the production department of Shell. He has worked in the natural gas and gasoline, production mechanical engineering, pipe line, drilling, refinery, and exploitation departments of Shell during his 32 years.

N. Rulison Knox, former vice chairman of the Bucyrus-Erie Company, has been named director and vice president in charge of steel operations of Husky Oil Company. Husky has bought the Gate City Steel Works of Omaha, Nebraska, and has entered the steel warehousing and fabrication business. Knox has been named president and will serve on the board of Gate City Steel.

Donald D. Wagman of the National Bureau of Standards has received the Deparement of Commerce Silver Medal for Meritorious Service. Award was made for "very valuable contributions to science and technology in the field of chemical thermodynamics in the collection, calculation, and compilation of thermodynamic data."

For the last fifteen years, Wagman has been concerned with the development of chemical thermodynamics.

Donald L. Campbell, formerly chief process engineer of Esso Engineering department has been named associate director of the process division. A graduate of Iowa State and Massachusetts Institute of Technology, Campbell joined the Development Company in 1928.

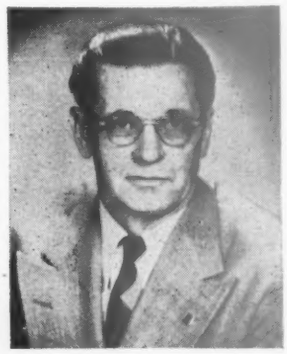
Burton C. Belden, formerly an assistant director of the process division, will succeed Campbell. Belden, a graduate of Hamilton College and Cornell University, joined the process division and in 1947 was appointed assistant director.

R. S. Piroomov, formerly manager of technical service division, East Coast Manufacturing, Esso Standard, was named assistant director of the process division, replacing Belden. He joined Esso Standard in 1927. He was graduated from MIT. In 1945 he was appointed assistant manager of technical service division, and its manager in 1950.

F. William Schumacher, formerly associate director of the process division, was named manager of the technical service division of Esso Standard's East Coast manufacturing division replacing Piroomov.

Margaret Howard

Betty Hartman



Jim Carll

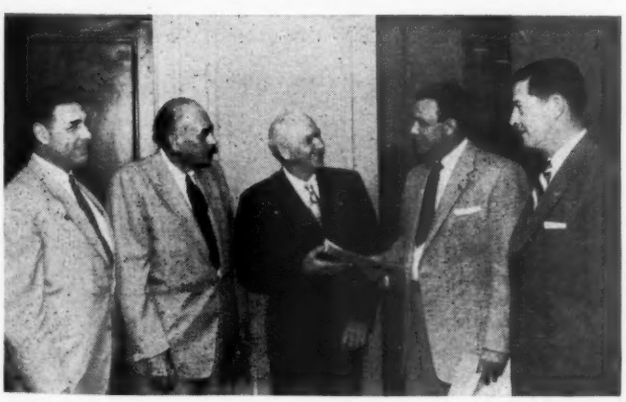
Margaret Howard is national president of the Jane Phillips Sorority, a group composed of women employees of Phillips Petroleum Company, which is holding its 12th annual convention in Denver, Colorado in June. She previously had served on the national Grand Council for two years as secretary and one year as editor and coordinator of the sorority's monthly publication — "Janues." A charter member of the Salt Lake City chapter, she was the leader in forming that chapter in 1949 and was its first president. She also served as Salt Lake City's local Janues reporter one year.

Mrs. Howard is secretary to the division manager, Wasatch sales division of Phillips, and has been affiliated with Phillips sales department in this capacity for the last six years.

Betty Hartman is convention chairman of the Jane Phillips sorority. She is a charter member of the organization's Denver chapter, and has served as that chapter's president, vice president, and treasurer. Nationally, she served on the JPS Grand Council for a year as treasurer. Mrs. Hartman became associated with the oil industry when Phillips opened its division sales office at Denver in 1947.

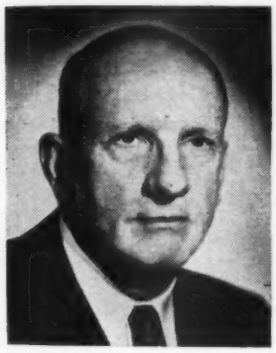
The sorority was organized in 1937, and was named for the late Jane Gibson Phillips, first sponsor and wife of the founder of the firm.

Jim Carll, former oil editor of the San Angelo Standard-Times, San Angelo, has joined Lone Star Gas Company's advertising staff at Dallas. Carll's special field will be that of development and dissemination of public information having to do with the company's operations and personnel. Prior to his association with the San Angelo Standard-Times, Carll owned and operated the News Publishing Company, McCamey.



Induction ceremonies at Los Angeles Nomads' March meeting. Attending are: Ox Morgan, Falcon Products, sergeant-at-arms; Ernest E. Williams, Technical Oil Tool; Truman A. Beeson, Specialty Sales; Joe Schlarb, Chiksan Company, vice president and ritual master, and John Flanagan, Johnston Testers, president. Guest speaker and international guests, at right, were: Standing: S. J. Veenstra and A. Nilsson, Asiatic Petroleum; Harold C. Devenish, Trinidad Oilfield Service; J. D. Rowe, Iraq Petroleum; Harry Bartlett, Dunlap and Graham, Peru; Karl B. Jauman, Iraq. Seated, O. S. Woodward, Drilexco, Brazil; T. G. Schad, Asiatic Petroleum; Robert L. Temple, Republic Supply, speaker; W. R. Grimes, Vacuum, Venezuela; James R. Dabney, Union Oil, Peru.

XUM



Henry Cortes

H. F. Sinclair

John G. McLean

▸ **Henry C. Cortes** has been elected to the board of directors of Magnolia Petroleum Company. Cortes will be executive in charge of Magnolia's research efforts in addition to his duties as assistant manager of the company's exploration division. Cortes attended the University of the South at Sewanee, Tennessee, and first began in the oil business in 1922, as a member of a rotary drilling crew in the Hull Salt Dome field of Liberty County.

▸ **H. F. Sinclair,** founder of the Sinclair Oil Corporation and board member since it was organized in 1916, will retire from the board with the expiration of his present term on May 19.

In January 1949, Sinclair retired as president of the company and was succeeded by P. C. Spencer. He continued as a member of the board, however, and as its honorary chairman. At the time Sinclair organized the company, its assets were $51,000,000, compared with assets of $1,140,665,152 reported at the end of 1953.

Born in Wheeling, West Virginia, Sinclair went to Independence, Kansas, with his family at an early age and after taking pharmacy at the University of Kansas worked for a while in his father's drug store. He soon became interested in the booming oil business, went to Oklahoma and reportedly was a millionaire by the age of 35. Five years later he went to New York and organized Sinclair.

To fill the vacancy created by Sinclair's retirement, the board has nominated **William Gage Brady, Jr.,** former chairman and president of the National City Bank of New York, to head the oil company.

Directors will be elected at the company's annual meeting in New York.

▸ **John G. McLean,** professor of business administration at Harvard University, will serve as an assistant to the president of Continental Oil Company while on leave of absence from Harvard. McLean, who has been associated with Harvard's graduate school of business administration since 1940, has for the past seven years taught advanced courses dealing with the organization of industries, and the impact of changes made by technologies and competition on management policies.

During his association with Continental McLean will conduct special studies concerning the company's programs, policies and procedures. He will make his headquarters in Houston.

▸ **Reynold M. Kress,** president, general manager, and director of the East Jersey Railroad and Terminal Company, a subsidiary of Tide Water Associated Oil Company, has retired. Kress joined Tide Water in 1918.

▸ **T. H. Barton** was named chairman of the board, Lion Oil Company; **T. M. Martin,** president; **A. F. Reed,** vice president; **J. E. Howell,** vice president; **R. E. Meinert,** vice president; **C. N. Barton,** vice president; **Jeff Davis,** secretary; **E. W. Atkinson,** treasurer; **E. P. Marrable,** assistant secretary and assistant treasurer; **B. L. Allen,** assistant secretary, and **W. M. Rodman,** assistant treasurer. Election was held at recent stockholders meeting.

▸ **P. E. Lakin,** vice president and director of Shell Oil Company, has retired. He has been with the company for 39 years, having begun his career in the Northwest in 1915. He was made a vice president in 1936 and a director in 1945.

S. F. Bowlby, vice president in charge of exploration and production for the Pacific Coast area, will become the senior Shell officer on the West Coast. Bowlby is a graduate of the University of Oklahoma. He joined Shell in 1926. In 1946 he became a vice president of the Shell Oil Company, which position he has held ever since.

▸ **Harold F. Clary** has been elected a member of the board of directors of Signal Oil and Gas Company. A 20-year man with Signal, he has been a member of the legal staff during that entire time and for the past several years has served as assistant secretary. He was graduated from the University of California.

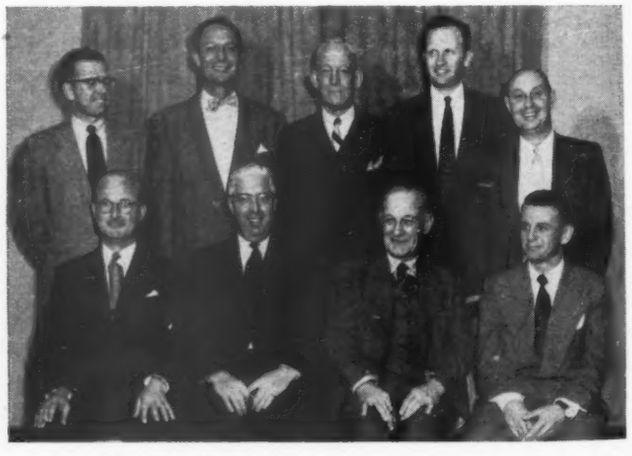
▸ **Arthur G. Gilkes** has become a senior patent attorney in the development and patent department of Standard Oil Company (Indiana) at Chicago. He had been a partner in the patent law firm of Adams, Forward and McLean, New York, since 1949. Previously he was with Pennie, Edmonds, Morton and Barrows, New York. Gilkes was graduated from Princeton University.

▸ **F. W. Stewart** is Cities Service Oil Company's new field representative for its crude oil supply division in Louisiana. Stewart will have headquarters at New Orleans. He joined Cities Service in 1936 and has worked in both the secretary's and the treasurer's division at Bartlesville since then. He was named assistant cashier for the company in 1951.

He succeeds **R. M. Foster,** who was transferred from the New Orleans post to the Bartlesville headquarters office.

▸ **Harry G. Smith,** special assistant to Sun Oil's director of industrial relations, has been appointed assistant superintendent in charge of personnel at Sun's Marcus Hook, Pennsylvania, refinery. Smith became associated with Sun when he took a summer assignment as assistant labor relations coordinator at Marcus Hook in 1949 while a professor of economics at Bucknell University.

J. R. Taylor, Socony-Vacuum, retired, was honored guest at New York Chapter of Nomads' April 5 meeting. Taylor, fifth from left, is with: James A. Thomas, New York Nomad; E. W. Beck, Socony-Vacuum; Henry J. McAdams, New York Nomad; Joe L. Comer, William Powell, sergeant-at-arms; Stewart D. Beckley, Beckley, Haltom and Hickman, and C. F. Beatty, Socony-Vacuum.



Above, visitors at the meeting were: Standing, Frank Wright, Texaco, Venezuela; T. C. Lemcke, Reed Roller Bit, Los Angeles; C. L. Clark, Socony-Vacuum, Egypt; Charles Pugsley, Esso, Louisiana; Stanley Cook, England. Seated, W. H. A. Dalton, England; W. Baker, Lago Oil and Transport, Aruba, N. W. I.; C. H. Holgen, The Netherlands, and Pete Loakes, Texaco, Venezuela.

Personals

Earle W. Gard, widely known in the petroleum and chemical industries, has left for the Mediterranean, Middle East, and Turkey, to continue a study of economic conditions and business opportunities in these areas. Gard maintains offices in Los Angeles, California, and Ankara, Turkey.

E. W. Gard

He negotiated the contract for Turkey's first petroleum refinery, now under construction, and has a son currently working on the project.

B. M. Owen has been named assistant treasurer, Creole Petroleum Corporation, an affiliate of Standard Oil Company (New Jersey). Owen began his career with Jersey Standard interests in 1937.

W. A. M. Greeven has been named director of Creole. Greeven joined the Standard Jersey in 1925.

At the same time, Creole announced resignation as a director and vice president of **Dr. Cecil L. Burrill,** who has returned to the Standard to become manager of the general economics department.

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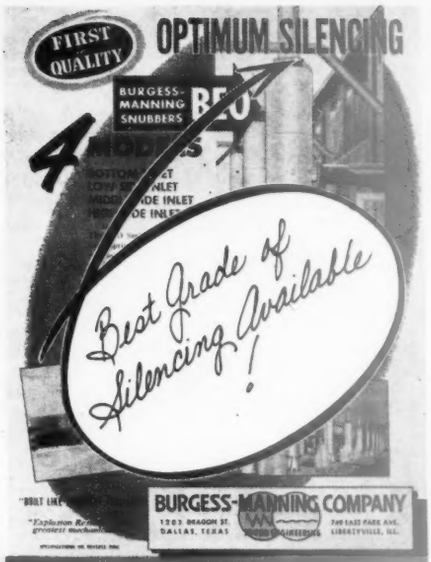

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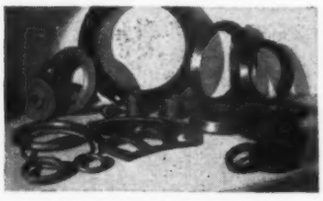
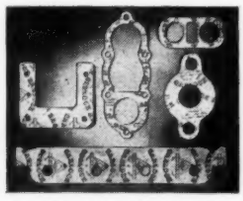
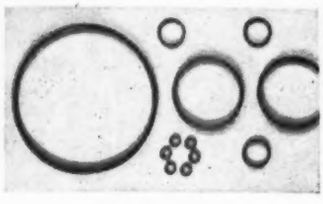


Molded Rubber Gasketing Devices

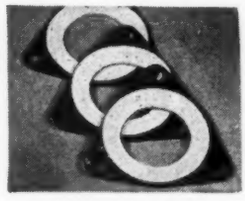


Duck Inserted Rubber Gaskets

Cork-Fibre Sheet



"O" Ring Gaskets



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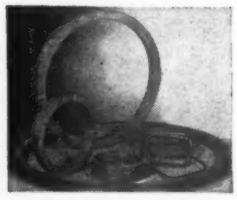

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DEATHS

Louis A. Brouilette of The Second National Bank oil and gas department, died of a heart attack at his home, April 4. Brouilette, 54, had been with Second National since 1947 and held a wide circle of business friends in the oil and gas fields.

Pierre Samuel du Pont, industrialist, philanthropist, and head of the du Pont family, died unexpectedly April 5. He was 84 years old.

Pierre S. du Pont acquired E. I. du Pont de Nemours and Company, at the turn of the century with his two cousins, Alfred I. and T. Coleman du Pont. They began the transformation of the company, already 100 years old, from a maker of black powder to one of the greatest chemical enterprises in the world, with more than 90,000 employees and 145,000 stockholders. Pierre du Pont was a director and honorary chairman of the board of the company at his death.

H. P. Carroll of Houston, operating manager of the Texas distribution division of United Gas Corporation, died in a hospital at Rochester, Minnesota, April 6. His death ended a long career in the gas industry which began in 1911 when as a youth of 18 he went to work as a map maker for the old Beaumont Gas Light Company. Since 1930, Carroll had been an executive with United Gas Corporation and predecessor companies in Houston.

Arthur C. Mengel, chief chemical engineer of the American Locomotive Company, died suddenly March 20, of a heart attack. Mengel joined American Locomotive in 1915, as assistant chief chemist, having previously worked for the Bethlehem Steel Company. He became chief chemist of the company in 1935.

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BOOKS ★

Catalysis, Volume 1; **Fundamental Principles,** Part 1, *by Paul H. Emmett. Reinhold Publishing Corporation, 330 West 42nd St., New York 36, New York. Pages, 410. Price, $10.*

This new volume in an important series, on an all-important subject, was prepared under the direction and chief editorship of Emmett, of the Gulf Research and Development Mellon Institute. Contributing editor-authors are Herman Ries, Keith Laidler, W. B. Innes, F. G. Ciapetta, C. J. Plank, and P. W. Selwood. It undertakes with excellent success to treat of physical absorption, chemisorption, catalyst surface area measurement; the kinetic laws in surface catalysis, reaction rates, catalyst carriers; promoters, poisons, and inhibitors. These are some of the subjects covered. Mathematical derivations and tabular data are supplied extensively, and bibliographies total more than 950 references in all, of which more than 250 are in the chapter on "Catalyst Preparation," one of the most interesting of the chapters, written by Ciapetta and Plank. Another important and extensive chapter is that by Laidler on kinetics in surface catalysis, wherein a large number of specific reactions are discussed in considerable detail.

"Though catalysis has not yet been placed on a firm scientific foundation," says Editor-Author Emmett prefatorily, "the signs of progress are numerous and unmistakable."

Tables of Lagrangian Coefficients for Sexagesimal Interpolation, *by National Bureau of Standards Applied Mathematic Series 35. Pages, 157. Price, $2. (Order from the Government Printing Office, Washington 25, D. C.)*

The Lagrangian interpolation formula is a tool of fundamental importance in problems of interpolation. Although many and extensive tables of Lagrangian interpolation coefficients have been provided for decimal subdivisions of the argument, few corresponding tables are available for arguments in sexagesimal measure, such as angles given in units of degrees, minutes, and seconds. Even though interpolation is possible, it is a cumbersome operation to find the required coefficients in existing tables.

Present tables eliminate the need for repeated interpolation.

Condensate Well Corrosion, *by Condensate Well Corrosion Committee, Natural Gasoline Association of America, Kennedy Building, Tulsa, Oklahoma. Pages, 200. Single copies, $6; Ten or more copies, $5.50 each.*

This outstanding book, the most important ever published in its field, reports the extensive findings of the work of the industry over a 10-year period, in the determination of causes, and of cures, for baffling corrosion problems experienced in especially condensate wells. Its results are applicable also to plants and equipment where corrosion due to weak acids, carbon dioxide, etc., are found and that cause trouble.

Fifteen chapters are completed in the book, covering every phase of the problem. The research programs cost the industry a great number of thousands of dollars and thousands of man-hours of work and research. The book presents the compendium of current knowledge of the mechanism of anaerobic corrosion, and shows the effects of this corrosion on various alloys of steel in the systems studied. Inhibitors for this corrosion are studied, also injection methods, well completion methods, metallurgical factors that influence the situation.

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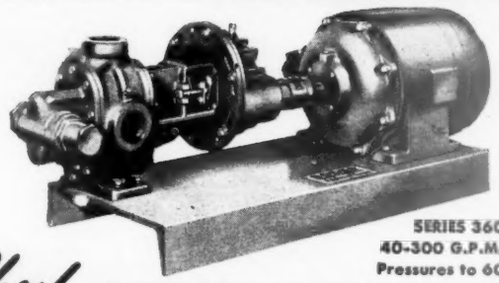

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LAUGH with BARNEY

He: I like "Buttons and Bows."
She: I like only beaux.
He: What's the matter with buttons?
She: They bother my beaux.

* * *

An enterprising sailor offered to smuggle a young woman to Hawaii, and hid her in a lifeboat. After several days and nights had passed, with the sailor spending most of his time with the girl, she began to worry why they didn't reach their destination.

Finally, she went to the captain of the boat and confessed and told him the whole story. Then she asked: "When do we get to Honolulu?"

"Lady," the captain said. "This is the Seattle-Bremerton ferry."

* * *

A stenographer is a girl you teach to spell while she is looking for a husband.

* * *

Wife: The maid quit. She said you spoke to her insultingly over the phone.
Hubby: Ye gods! I thought I was talking to you.

* * *

A small boy was asked to dine at the home of his teacher. His mother asked him on his return:

"You are sure you didn't do anything that was ill-mannered?"

"Why, no, mother — nothing to speak of."

"Then something *did* happen?"

"Well, while I was trying to cut the meat, it slipped off to the floor. But I carried the situation off all right."

"What did you do?"

"Oh, I just said carelessly-like, 'That's always the way with tough meat.' "

The trained laborer was making application for work with a fairly large firm, and asked his prospective boss, "Does your company pay my Blue Cross insurance?"

"No, you pay for it; it's deducted in monthly payments from your wages," he was informed.

"Last place I worked they paid it," the workman said, truculently.

"Did they give you rest periods, too?"

"Sure."

"Life insurance?"

"Sure."

"Bonusus?"

"Yes, and three-week vacations, and sick leave, and gifts for —"

"Why did you leave?"

"The company folded."

* * *

The little man was pushing his cart through the crowded market.

"Coming through," he called merrily. No one moved.

"Gangway!" he shouted. A few men stepped aside.

Ruefully he surveyed the situation and then smiled as a bright idea struck him.

"Watch your nylons!" he warned. The women scattered like chaff in the wind.

* * *

There's one thing to be said for ignorance — it sure causes a lot of interesting arguments.

* * *

Young actor: Dad, I've got my first part in a play. I play the part of a man who has been married for 20 years.

Father: Splendid. Maybe one of these days they'll give you a speaking part.

"I DUNNO - I JUST CALLED IN LANE-WELLS AND THEY PERFORATED"

A very handsome young chap was recently hired in a large accouting firm. In a while the young man came to Mr. Ledger, his department head, and said, "I am sorry to tell you, but some of the young ladies in this office are tempting me sorely."

"Be firm, young man," was the reply, "and you'll get your reward in the Future." A few weeks later, the lad complained again. "Mr. Ledger," he said, "I don't know what to do. This time it's that beautiful redhead who is pursuing me." "Resist, my son and you will get your reward in the Future." "I don't know how much longer I can resist," the young man said. "By the way, sir, what do you think this reward will be that I will get in the Future?" The answer came quickly, "A bale of hay, you jackass!"

* * *

The salesgirl explained it this way: "If you remove the bodice, you will have a playsuit. If you remove the skirt, you will have a sunsuit. If you remove anything else, you'll have a lawsuit."

* * *

A street cleaner was fired for daydreaming . . . he couldn't keep his mind in the gutter.

* * *

Old maids, it is said are born — not made.

* * *

"When I was in India," said the club bore, "I saw a tiger come down to the water where some women were washing clothes. It was a very fierce tiger, but one woman, with a great presence of mind, splashed some water in its face — and it slunk away."

"Gentlemen," said a man in an armchair, "I can vouch for the truth of this story. Some minutes after this incident I was coming down to the water. I met this tiger, and, as is my habit, stroked its whiskers. Gentlemen, those whiskers were wet."

* * *

A young city lawyer was about to vacation with his family at their country cottage. One thought plagued him. So many friends and relatives visited him at his cottage the previous summers that his budget had snapped and rest was impossible. With this in mind he wired thirty people who had been his guests: "Need $300 badly. Please forward same immediately."

He harvested 30 new alibis which he read with relish while enjoying his first vacation in years.

* * *

A certain Western auto dealer sold two cars to the same man in one day. His customer was an Indian suddenly grown rich from oil which had spouted on his land.

The red-man bought a high-powered car, and with a gallon of gin in the front seat, fared forth to see the world. In about an hour, he came back bleeding and bruised, ready to buy another car.

"For heaven's sake, what happened?" the dealer inquired.

"Down road piece," said the red-man, "fences come fast. Telephone poles come fast. Soon bridge come down road. I turn to let go by. Need new car."

UNIVERSAL CONVERSION FACTORS

BARREL OF CEMENT (Continued)

158,987.1459456	milliliters
158,987.1459456	cubic centimeters
158,987,145.9456	cubic millimeters
0.188	tons (short)
0.16796	tons (long)
0.170551	tons (metric)
170.55097	kilograms
376	pounds
17.0551	hektograms
1.70551	dekagrams
6,016	ounces
0.170551	grams
0.0170551	decigrams
0.00170551	centigrams
0.000170551	milligrams

BARREL PER DAY =

0.041667	barrels per hour
0.00069444	barrels per minute
0.000011574	barrels per second
0.1589871	kiloliters per day
0.0066245	kiloliters per hour
0.00011041	kiloliters per minute
0.000001840	kiloliters per second
0.1589871	cubic meters per day
0.0066245	cubic meters per hour
0.00011041	cubic meters per minute
0.000001840	cubic meters per second
0.20794	cubic yards per day
0.0086642	cubic yards per hour
0.0001444	cubic yards per minute
0.0000024067	cubic yards per second
1.589871	hektoliters per day
0.066245	hektoliters per hour
0.0011041	hektoliters per minute
0.00001840	hektoliters per second
5.6146	cubic feet per day
0.233942	cubic feet per hour
0.00389903	cubic feet per minute
0.0000649838	cubic feet per second
15.89871	dekaliters per day
0.66245	dekaliters per hour
0.011041	dekaliters per minute
0.0001840	dekaliters per second
42	gallons (U. S.) per day
1.71875	gallons (U. S.) per hour
0.029167	gallons (U. S.) per minute
0.0004861	gallons (U. S.) per second
34.99089	gallons (Imperial) per day
1.45795	gallons (Imperial) per hour
0.024299	gallons (Imperial) per minute
0.00040499	gallons (Imperial) per second
168	quarts (U. S.) per day
6.875	quarts (U. S.) per hour
0.11668	quarts (U. S.) per minute
0.0019444	quarts (U. S.) per second
158.98714	liters per day
6.6245	liters per hour
0.11041	liters per minute
0.001840	liters per second
158.98714	cubic decimeters per day
6.6245	cubic decimeters per hour
0.11041	cubic decimeters per minute
0.001840	cubic decimeters per second
336	pints per day
13.75	pints per hour
0.23336	pints per minute
0.0038888	pints per second
1,344	gills per day
55	gills per hour
0.933344	gills per minute
0.0155552	gills per second
1,589.87146	deciliters per day
66.245	deciliters per hour
1.1041	deciliters per minute
0.01840	deciliters per second
9,702.0288	cubic inches per day
404.2	cubic inches per hour
6.7375	cubic inches per minute
0.112292	cubic inches per second
15,898.7146	centiliters per day
662.45	centiliters per hour
11.041	centiliters per minute
0.1840	centiliters per second
158,987,145946	milliliters per day
6,624.5	milliliters per hour
110.41	milliliters per minute
1.84	milliliters per second
158,987.145946	cubic centimeters per day
6,624.5	cubic centimeters per hour
110.41	cubic centimeters per minute
1.840	cubic centimeters per second
158,987,145.946	cubic millimeters per day
6,624,500	cubic millimeters per hour
110,410	cubic millimeters per minute
1,840	cubic millimeters per second

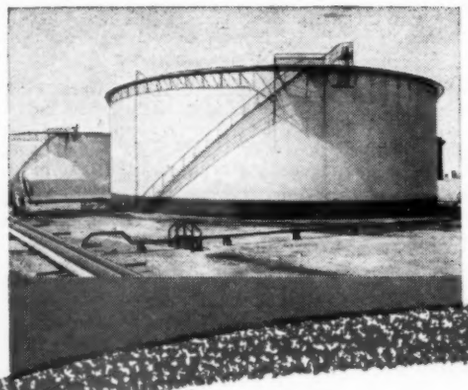
BARREL PER HOUR =

24	barrels per day
0.016667	barrels per minute
0.000277778	barrels per second
3.81567	kiloliters per day
0.1589871	kiloliters per hour
0.0026498	kiloliters per minute
0.000044163	kiloliters per second
3.81567	cubic meters per day
0.1589871	cubic meters per hour
0.0026498	cubic meters per minute
0.000044163	cubic meters per second
4.99056	cubic yards per day
0.20794	cubic yards per hour
0.0034657	cubic yards per minute
0.000057761	cubic yards per second
38.1567	hektoliters per day
1.589871	hektoliters per hour
0.026498	hektoliters per minute
0.00044163	hektoliters per second
134.7504	cubic feet per day
5.6146	cubic feet per hour
0.093577	cubic feet per minute
0.15596	cubic feet per second
381.567	dekaliters per day
15.89871	dekaliters per hour
0.26498	dekaliters per minute
0.0044163	dekaliters per second
1,008	gallons (U. S.) per day

Compiled by Steven Gerolde, Gulf Oil Corporation

the important factors in **floating roof design**

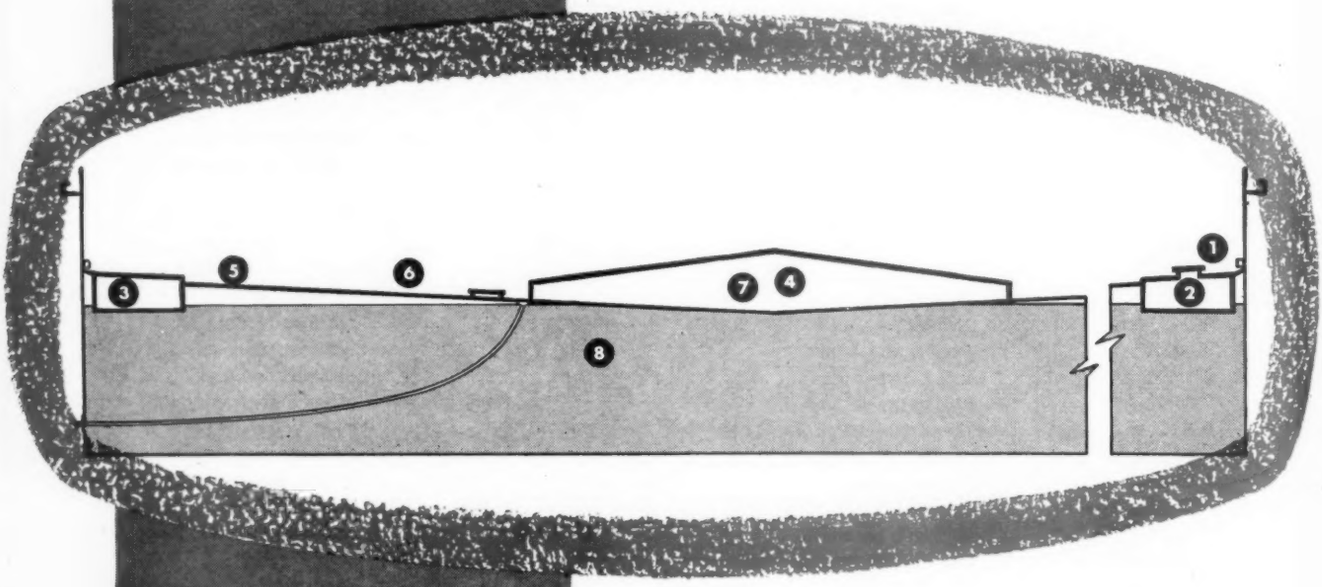
number 6 of a series

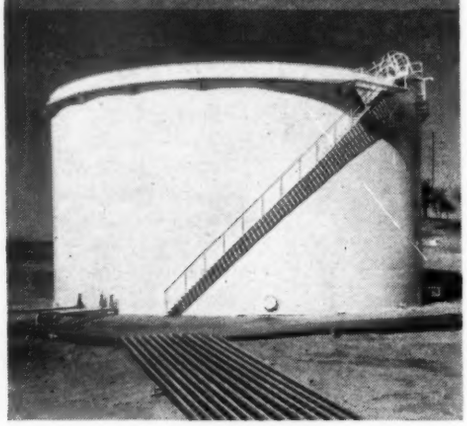


COMPARE

Wiggins Floating Roof Specifications

fact by fact with any other floating roof and you'll find that only the Wiggins meets every important design specification.





1. Well-designed, close-fitting seals; including primary, secondary, and top seals for maximum conservation.
2. Pontoons divided into large number of GAS-TIGHT compartments for safety.
3. Pontoon compartments deep and roomy so they may be easily entered and inspected for maintenance if necessary.
4. Pontoon compartments uncluttered with framework for easy inspection and maintenance.
5. COMPLETE CLEAN drainage.
6. Roof designed to take ALL LOADS to which structure may be subjected, with better than normal safety factor.
7. Pontoons designed to maintain buoyancy under all anticipated conditions.
8. Assure full use of the capacity of the tank for in and out storage.

Only Wiggins floating roofs meet every important design specification

WIGGINS VAPOR SEALS GENERAL AMERICAN TRADE MARK

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South La Salle Street • Chicago 90, Illinois

UNIVERSAL CONVERSION FACTORS

BARREL PER HOUR (Continued)

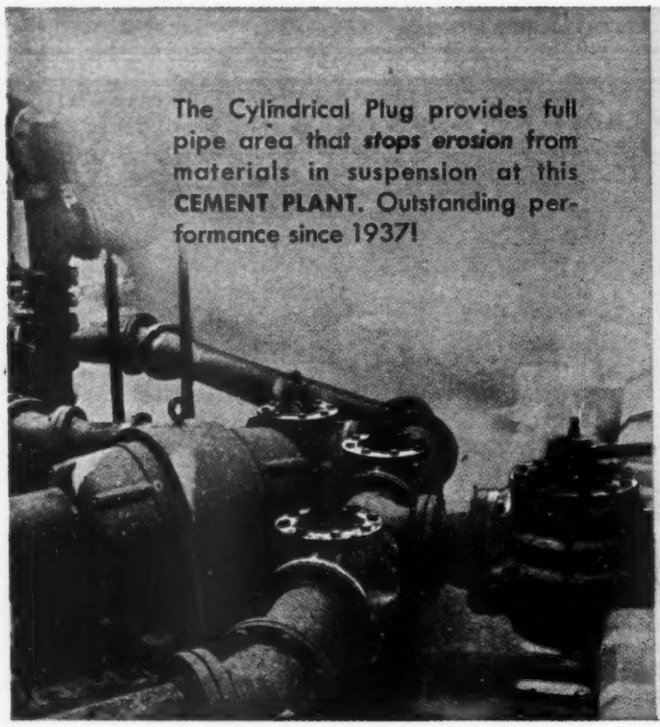
42	gallons (U. S.) per hour
0.7	gallons (U. S.) per minute
0.11667	gallons (U. S.) per second
839.78136	gallons (Imperial) per day
34.99089	gallons (Imperial) per hour
0.58318	gallons (Imperial) per minute
0.0097197	gallons (Imperial) per second
4,032	quarts (U. S.) per day
168	quarts (U. S.) per hour
2.80	quarts (U. S.) per minute
0.046667	quarts (U. S.) per second
3,815.6904	liters per day
158.98714	liters per hour
2.64979	liters per minute
0.044163	liters per second
3,815.6904	cubic decimeters per day
158.98714	cubic decimeters per hour
2.64979	cubic decimeters per minute
0.044163	cubic decimeters per second
8,064	pints per day
336	pints per hour
5.60	pints per minute
0.93333	pints per second
32,256	gills per day
1,344	gills per hour
22.40	gills per minute
0.37333	gills per second
38,156.904	deciliters per day
1,589.87146	deciliters per hour
26.49786	deciliters per minute
0.44163	deciliters per second
232,848	cubic inches per day
9,702.0288	cubic inches per hour
161.7014	cubic inches per minute
2.695	cubic inches per second
381,569.04	centiliters per day
15,898.7146	centiliters per hour
264.97858	centiliters per minute
4.4163	centiliters per second
3,815,690.4	milliliters per day
158,987.145946	milliliters per hour
2,649.78576	milliliters per minute
44.163	milliliters per second
3,815,690.4	cubic centimeters per day
158,987.145946	cubic centimeters per hour
2,649.78576	cubic centimeters per minute
44.163	cubic centimeters per second
3,815,690,400.0	cubic millimeters per day
158,987,145,946	cubic millimeters per hour
2,649,785.76	cubic millimeters per minute
44,163.096	cubic millimeters per second

BARREL PER MINUTE =

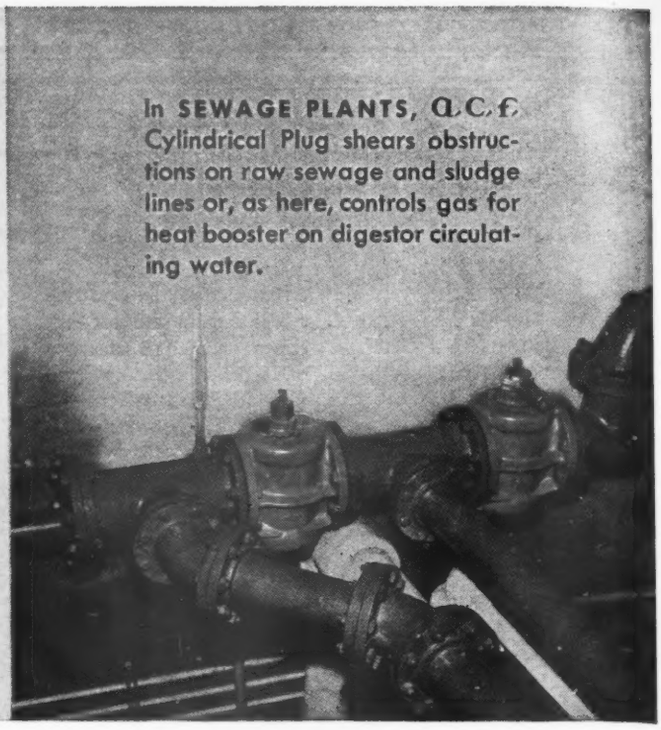
1,440	barrels per day
60	barrels per hour
0.016667	barrels per second
228.94272	kiloliters per day
9.53928	kiloliters per hour
0.158987	kiloliters per minute
0.0026498	kiloliters per second
228.94272	cubic meters per day
9.53928	cubic meters per hour
0.158987	cubic meters per minute
0.0026498	cubic meters per second
299.43648	cubic yards per day
12.47652	cubic yards per hour
0.20794	cubic yards per minute
0.0034657	cubic yards per second
2,289.4272	hektoliters per day
95.3928	hektoliters per hour
1.58987	hektoliters per minute
0.026498	hektoliters per second
8,085.05280	cubic feet per day
336.8772	cubic feet per hour
5.6146	cubic feet per minute
0.093577	cubic feet per second
22,894.272	dekaliters per day
953.928	dekaliters per hour
15.8987	dekaliters per minute
0.26498	dekaliters per second
60,480	gallons (U. S.) per day
2,520	gallons (U. S.) per hour
42	gallons (U. S.) per minute
0.7	gallons (U. S.) per second
50,386.7520	gallons (Imperial) per day
2,099.4480	gallons (Imperial) per hour
34.99089	gallons (Imperial) per minute
0.58318	gallons (Imperial) per second
241,920	quarts per day (U. S.)
10,080	quarts per hour (U. S.)
168	quarts per minute (U. S.)
2.80	quarts per second (U. S.)
228,941.48966	liters per day
9,539.22874	liters per hour
158.987146	liters per minute
2.64979	liters per second
228,941.48966	cubic decimeters per day
9,539.22874	cubic decimeters per hour
158.987146	cubic decimeters per minute
2.64979	cubic decimeters per second
483,840	pints per day
20,160	pints per hour
336	pints per minute
5.60	pints per second
1,935,360	gills per day
80,640	gills per hour
1344	gills per minute
22.40	gills per second
2,289,414.89664	deciliters per day
95,392.28736	deciliters per hour
1,589.87146	deciliters per minute
26.49786	deciliters per second
13,970,921.472	cubic inches per day
582,121.7280	cubic inches per hour
9 702.0288	cubic inches per minute
161.70048	cubic inches per second
22,894,148.9664	centiliters per day
953,922.8736	centiliters per hour
15,898.71459	centiliters per minute
264.97858	centiliters per second
228,941,489.664	milliliters per day
9,539,228.736	milliliters per hour
158,987.14595	milliliters per minute
2,649.78576	milliliters per second
228,941,489.664	cubic centimeters per day
9,539,228.736	cubic centimeters per hour
158,987.14595	cubic centimeters per minute

Compiled by Steven Gerolde, Gulf Oil Corporation

XUM



The Cylindrical Plug provides full pipe area that ***stops erosion*** from materials in suspension at this **CEMENT PLANT.** Outstanding performance since 1937!



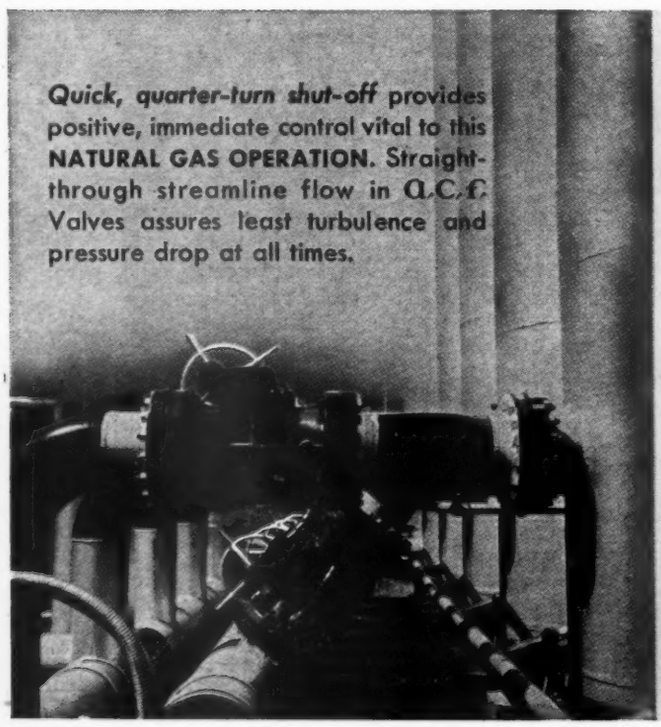
In **SEWAGE PLANTS,** a.c.f. Cylindrical Plug shears obstructions on raw sewage and sludge lines or, as here, controls gas for heat booster on digestor circulating water.

PROOF OF SUPERIORITY

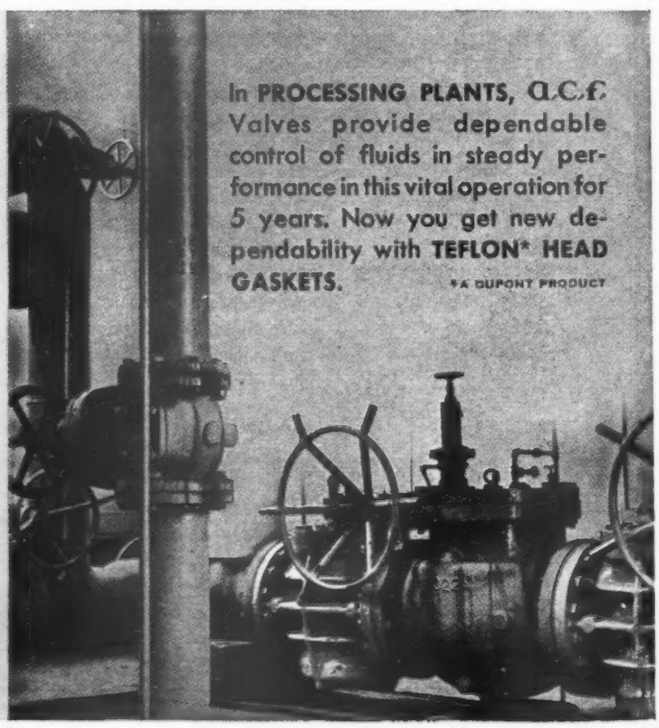
a.c.f. CYLINDRICAL FULL PIPE AREA PLUG VALVES

Representatives in 50 Principal Cities

Write for descriptive Catalog 4.7E to American Car and Foundry Company, Valve Division, 1501 E. Ferry Avenue, Detroit 11, Michigan.



Quick, quarter-turn shut-off provides positive, immediate control vital to this **NATURAL GAS OPERATION.** Straight-through streamline flow in a.c.f. Valves assures least turbulence and pressure drop at all times.



In **PROCESSING PLANTS,** a.c.f. Valves provide dependable control of fluids in steady performance in this vital operation for 5 years. Now you get new dependability with **TEFLON* HEAD GASKETS.**

*A DUPONT PRODUCT

UNIVERSAL CONVERSION FACTORS

BARREL PER MINUTE (Continued)

2,649.78576	cubic centimeters per second
228,941,489,664	cubic millimeters per day
9,539,228,736	cubic millimeters per hour
158,987,145.946	cubic millimeters per minute
2,649,785.76	cubic millimeters per second

BARREL PER SECOND =

86,400	barrels per day
3,600	barrels per hour
60	barrels per minute
13,736.47680	kiloliters per day
572.35320	kiloliters per hour
9.53922	kiloliters per minute
0.158987	kiloliters per second
13,736.47680	cubic meters per day
572.35320	cubic meters per hour
9.53922	cubic meters per minute
0.158987	cubic meters per second
17,966.0160	cubic yards per day
748.5840	cubic yards per hour
12,47640	cubic yards per minute
0.20794	cubic yards per second
137,364.7680	hektoliters per day
5,723.5320	hektoliters per hour
95.3922	hektoliters per minute
1.58987	hektoliters per second
485,101.44	cubic feet per day
20,212.560	cubic feet per hour
336.8760	cubic feet per minute
5.6146	cubic feet per second
1,373,648.5440	dekaliters per day
57,235,356	dekaliters per hour
953.92260	dekaliters per minute
15.89871	dekaliters per second
3,628,800	gallons (U. S.) per day
151,200	gallons (U. S.) per hour
2,520	gallons (U. S.) per minute
42	gallons (U. S.) per second
3,023,212.8960	gallons (Imperial) per day
125,967.2040	gallons (Imperial) per hour
2,099.45340	gallons (Imperial) per minute
34.99089	gallons (Imperial) per second
14,515,200	quarts (U. S.) per day
604,800	quarts (U. S.) per hour
10,080	quarts (U. S.) per minute
168	quarts (U. S.) per second
13,736,489.4144	liters per day
572,353.7256	liters per hour
9,539.22876	liters per minute
158.987146	liters per second
13,736,489.4144	cubic decimeters per day
572,353.7256	cubic decimeters per hour
9,539.22876	cubic decimeters per minute
158.987146	cubic decimeters per second
29,030,400	pints per day
1,209,600	pints per hour
20,160	pints per minute
336	pints per second
116,121,600	gills per day
4,838,400	gills per hour
80,640	gills per minute
1,344	gills per second
137,364,894.144	deciliters per day
5,723,537.256	deciliters per hour
95,392.28754	deciliters per minute
1,589.87146	deciliters per second
838,255,288.320	cubic inches per day
34,927,303.6800	cubic inches per hour
582,131.7280	cubic inches per minute
9,702.0288	cubic inches per second
1,373,648,941.440	centiliters per day
57,235,372.56	centiliters per hour
953,922.8754	centiliters per minute
15,898.71459	centiliters per second
13,736,489,414.40	milliliters per day
572,353,725.6	milliliters per hour
9,539,228.760	milliliters per minute
158,987.14595	milliliters per second
13,736,489,414.4	cubic centimeters per day
572,353,725.6	cubic centimeters per hour
9,539,228.760	cubic centimeters per minute
158,987.14595	cubic centimeters per second
13,736,489,414,400	cubic millimeters per day
572,353,725,600	cubic millimeters per hour
9,539,228,754	cubic millimeters per minute
158,987,145.9456	cubic millimeters per second

CUBIC FOOT PER DAY =

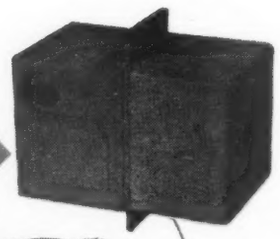
0.17811	barrels per day
0.0074214	barrels per hour
0.00012369	barrels per minute
0.0000020615	barrels per second
0.028317	kiloliters per day
0.0011799	kiloliters per hour
0.000019664	kiloliters per minute
0.00000032774	kiloliters per second
0.028317	cubic meters per day
0.0011799	cubic meters per hour
0.000019664	cubic meters per minute
0.00000032774	cubic meters per second
0.037036	cubic yards per day
0.0015432	cubic yards per hour
0.00002572	cubic yards per minute
0.00000042866	cubic yards per second
0.28317	hektoliters per day
0.011799	hektoliters per hour
0.00019664	hektoliters per minute
0.0000032774	hektoliters per second
1	cubic feet per day
0.041666	cubic feet per hour
0.00069444	cubic feet per minute
0.000011574	cubic feet per second
2.8317	dekaliters per day
0.11799	dekaliters per hour
0.0019664	dekaliters per minute
0.000032774	dekaliters per second
7.48050	gallons per day
0.31169	gallons per hour
0.0051948	gallons per minute
0.000086580	gallons per second
6.22889	gallons (Imperial) per day
0.25954	gallons (Imperial) per hour
0.0043256	gallons (Imperial) per minute
0.000072094	gallons (Imperial) per second
29.92257	quarts per day
1.24679	quarts per hour
0.020780	quarts per minute

Compiled by Steven Gerolde, Gulf Oil Corporation

XUM

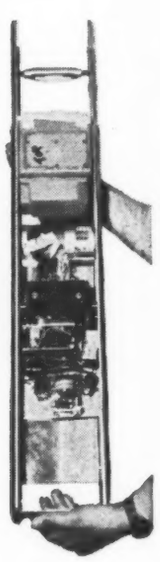
How's this

for compactness and vibration resistance in a precision instrument?



What happens at the bottom of a well shaft when oil drilling operations are under way? How do you evaluate the effectiveness of a new type drill almost two miles below the surface of the earth? Borg-Warner's Petro-Mechanics Research Division answers these questions by mounting a nine channel Consolidated recording oscillograph in the drill collar and sending it *down the hole*. Ten thousand feet underground this rugged, compact instrument accurately measures and clearly records such variables as acceleration, temperature, pressure, impact and vibration in their relationship to time and to each other. Equipped with CEC's widely known type 7-200 galvanometers, this miniaturized precision instrument combines high accuracy data recording ability with absolute minimum size and weight. The Model 5-118 is the smallest of 7 Consolidated multichannel recording oscillographs. For full details send for Bulletin 1500C-X15.

Model 5-118 shock mounted with associated instruments in unit 5" square by 30" in length.



Consolidated Engineering
CORPORATION
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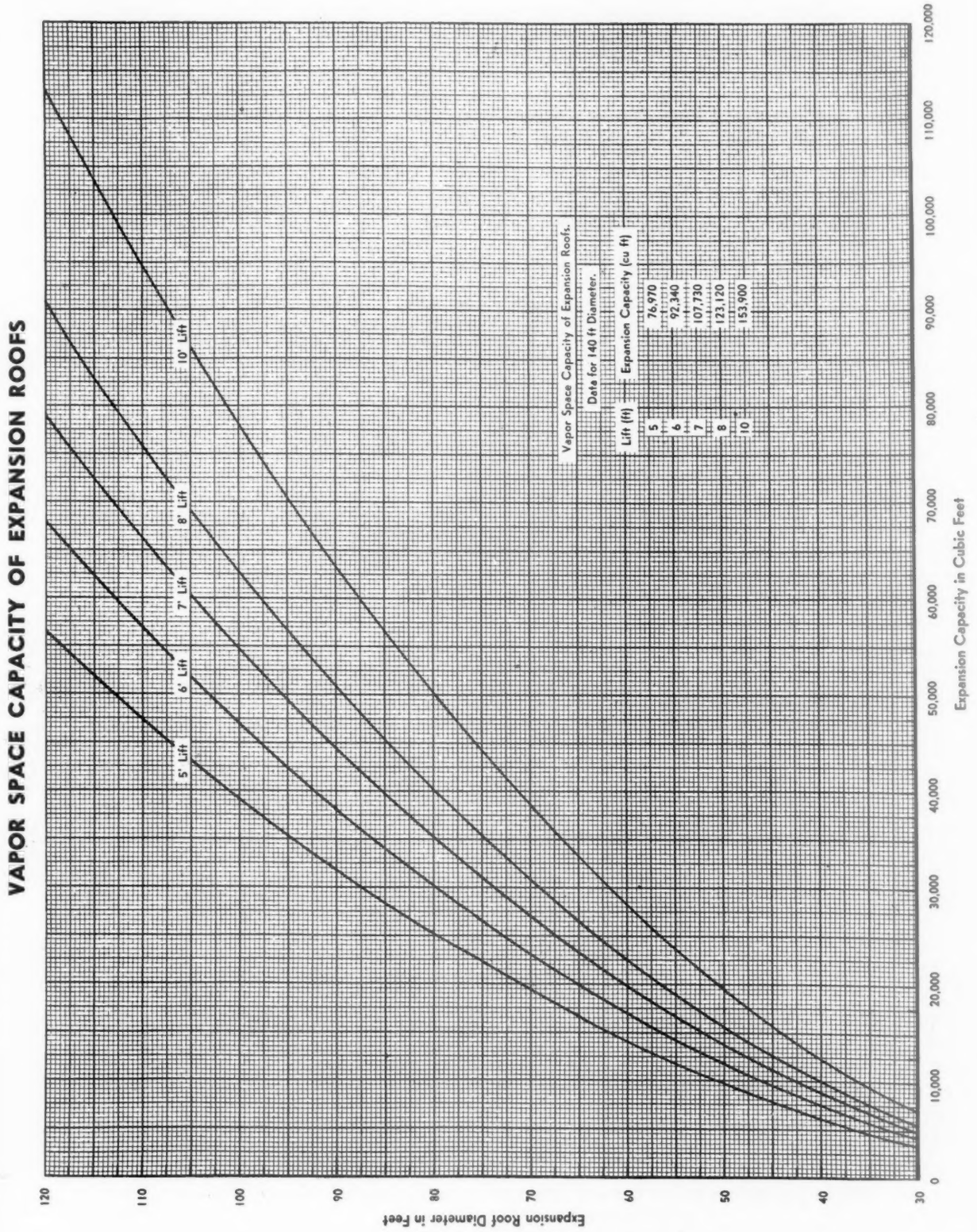

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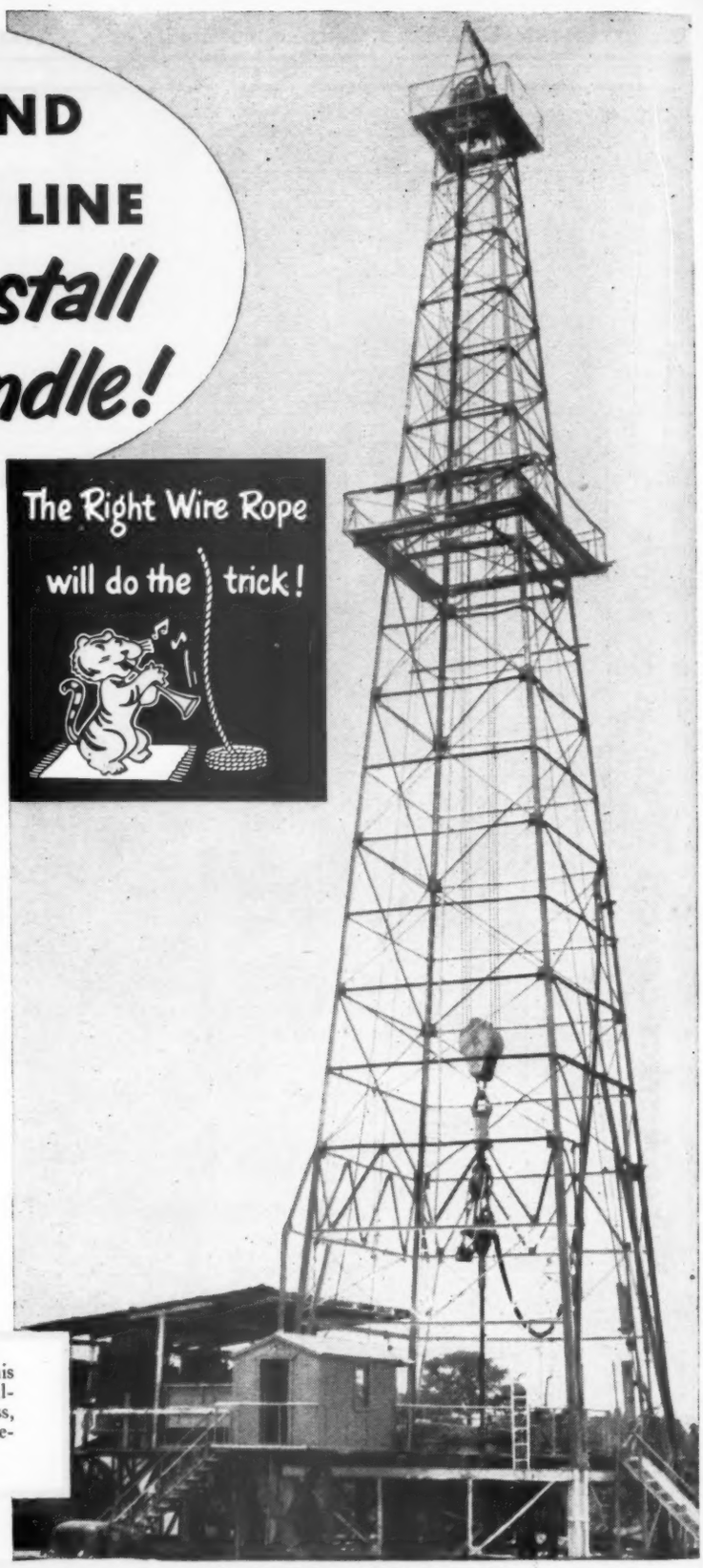
A TIGER BRAND EXCELLAY WIRE LINE *is easy to install ...easy to handle!*



● Every wire in a Tiger Brand Excellay Line is *preformed* to the shape it must assume in the finished rope. This eliminates the natural tendency of the wire to untwist and reduces the liveliness and twisting tendency of the finished line. As a result, Tiger Brand Excellay Line is easy to handle, and it resists kinking and fouling.

Excellay Preforming also increases the service life of your line. It removes internal stresses that lower the fatigue resistance of a line.

Tiger Brand Excellay Lines help you cut costs because they last long. When eventually they do need replacement, the job is done *quickly* because Excellay Preformed Line is easy to handle.

Be sure to specify Tiger Brand *Excellay* for your Rotary Drilling and Coring Lines, Casing Lines, Winch Lines, and Rod and Tubing Lines. Your American Wire Line Distributor can give you complete information.

EXCELLAY PREFORMED TIGER BRAND LINE was used on this 127 ft. rotary rig operating in the Doyle Pool, Pauls Valley, Oklahoma. Excellay Preforming reduces liveliness, twisting, and kinking. And it gives the line increased resistance to fatigue.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
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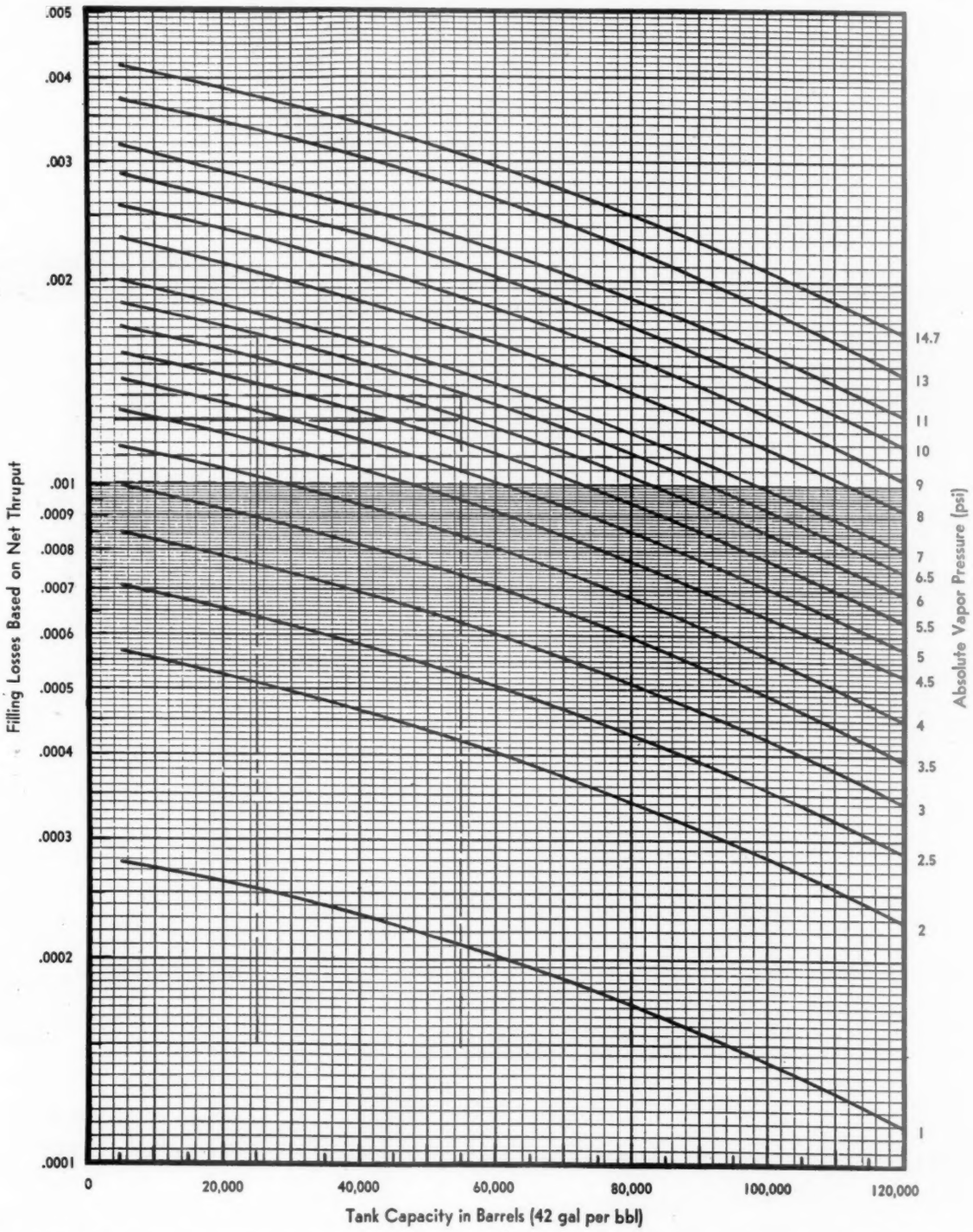
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S AMERICAN TIGER BRAND WIRE ROPE

Excellay Preformed

UNITED STATES STEEL

AVERAGE FILLING LOSSES FROM A MANIFOLDED EXPANSION ROOF SYSTEM



EXAMPLE: A 9-pound Reid Gasoline stored at an average atmospheric temperature of 67.5 F. Liquid Surface Temperature = 77.5 F. Absolute Vapor Pressure = 6.5 psia.

Rate of Loss from a system manifolded to a 55,000 bbl. Expansion Roof Tank = .00135 of net thruput. Total Loss = .00135 x 236,000 = 319 bbl.

LIMITATIONS: 1. The gasoline content of the vapor expelled during filling has been assumed as 25% greater than the average static concentration in aluminum painted standard size tanks, half full.

2. Based on average of available test data.

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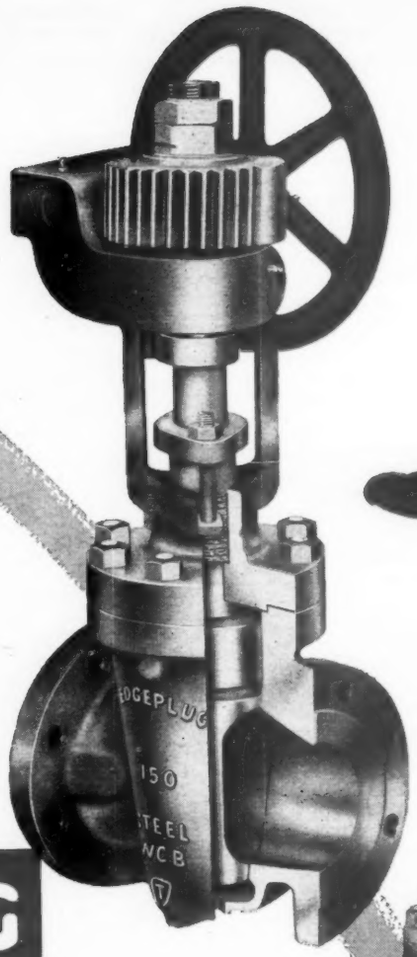
for

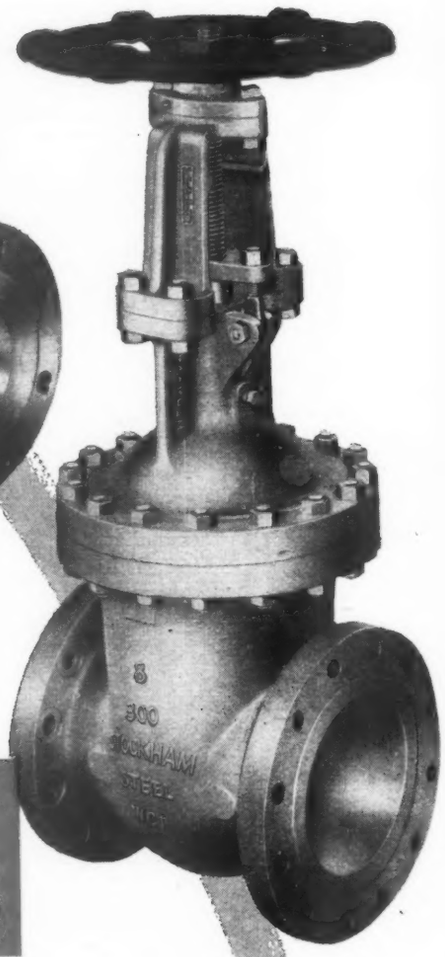
Dependable Service

SPECIFY



WEDGEPLUG
STEEL DRY PLUG VALVES

and



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ANALYSIS OF DRY BULB TEMPERATURES ON A TWELVE-HOUR BASIS

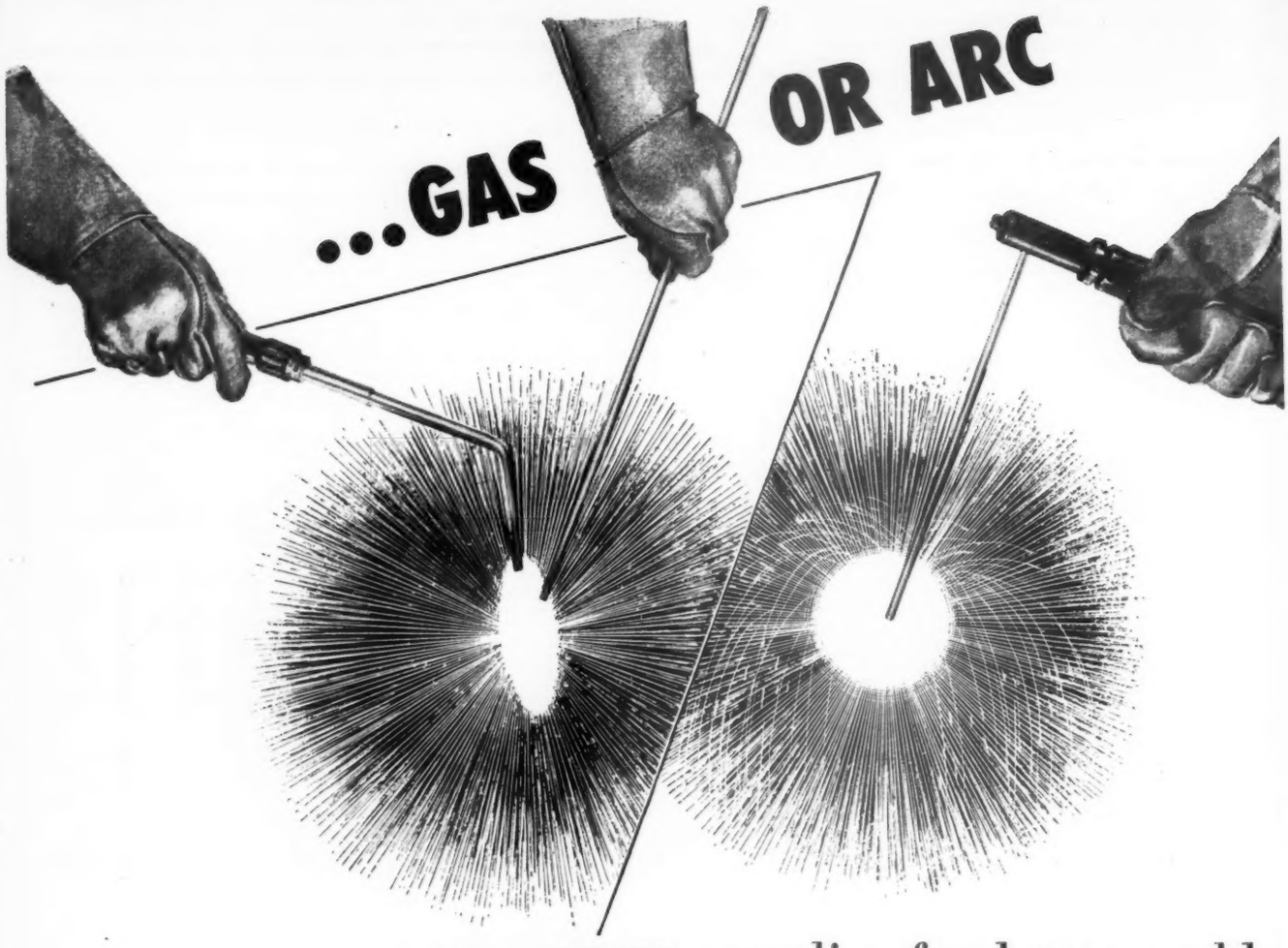
Number of Hours During Daily Periods Covered in June to September, Inclusive, of a Normal Year, That Dry Bulb Readings Will Equal or Exceed the Temperatures Shown in the Column Headings*†

State	City	Period Covered	110°	109°	108°	107°	106°	105°	104°	103°	102°	101°	100°	99°	98°	97°
Alabama	Mobile	1 P.M.- 1 A.M.														
Arizona	Phoenix	Noon-Midnight	31	48	65	93	110	201	256	331	395	459	532	583	629	689
Arkansas	Little Rock	1 P.M.- 1 A.M.								5	6	7	12	19	35	41
California	Fresno	Noon-Midnight	4	4	10	14	36	52	94	118	156	178	230	286	342	370
	Laguna Bch.	Noon-Midnight														
	Oakland	11 A.M.-11 P.M.														
	San Diego	Noon-Midnight														
	Williams	11 P.M.-11 A.M.	5	15	24	36	48	63	83	104	133	163	193	221	265	307
Colorado	Denver	11 A.M.-11 P.M.												3	5	7
	Grand Jctn.	Noon-Midnight									3	8	14	22	32	51
Dist. of Col.	Washington	Noon-Midnight												8	13	21
Florida	Jacksonville	1 P.M.- 1 A.M.												6	13	21
	Miami	10 A.M.-10 P.M.														
Georgia	Atlanta	1 P.M.- 1 A.M.										3	7	14	19	26
Idaho	Boise	Noon-Midnight		3	3	7	8	14	12	16	21	24	31	34	46	72
Illinois	Chicago	1 P.M.- 1 A.M.							3	4	7	10	15	21	28	33
	Moline	1 P.M.- 1 A.M.								5	10	13	21	28	41	50
Indiana	Evansville	1 P.M.- 1 A.M.										6	12	22	28	38
Kansas	Wichita	Noon-Midnight	5	8	12	23	32	52	77	112	133	161	198	237	273	299
Louisiana	New Orleans	1 P.M.- 1 A.M.														
	Shreveport	1 P.M.- 1 A.M.									4	9	23	31	50	81
Mass.	Boston	10 A.M.-10 P.M.														
Michigan	Detroit	10 A.M.-10 P.M.										4	6	8	10	14
Minnesota	St. Paul	1 P.M.- 1 A.M.									3	3	5	11	18	23
Mississippi	Jackson	1 P.M.- 1 A.M.							3	3	5	5	7	14	28	48
Missouri	Kansas City	1 P.M.- 1 A.M.		4	6	12	15	24	31	45	59	73	94	126	152	175
	Kirksville	11 A.M.-11 P.M.			4	7	13	20	29	39	48	55	75	86	95	107
	St. Louis	1 P.M.- 1 A.M.			5	5	8	11	16	23	29	40	54	77	101	118
	Springfield	1 P.M.- 1 A.M.													6	12
Montana	Helena	Noon-Midnight													4	4
Nebraska	North Platte	1 P.M.- 1 A.M.							6	7	19	23	34	46	63	83
	Omaha	1 P.M.- 1 A.M.			6	7	8	12	17	25	33	44	61	75	100	117
Nevada	Elko	11 A.M.-11 P.M.										4	9	18	33	39
	Reno	1 A.M.- 1 P.M.									4	4	10	14	28	42
New Jersey	Camden	1 A.M.- 1 P.M.											4	4	6	10
	Newark	10 A.M.-10 P.M.												3	8	8
New Mexico	Albuquerque	Noon-Midnight													4	15
New York	Albany	10 A.M.-10 P.M.														4
	Buffalo	1 P.M.- 1 A.M.														
	New York	10 A.M.-10 P.M.												3	4	6	10
N. Carolina	Raleigh	10 A.M.-10 P.M.													6	11
	Wilmington	10 A.M.-10 P.M.														
N. Dakota	Fargo	1 P.M.- 1 A.M.			3	3	5	5	7	11	17	23	30	30	41	41
Ohio	Cincinnati	10 A.M.-10 P.M.					3	3	4	5	10	11	14	22	31	46
	Cleveland	10 A.M.-10 P.M.										3	3	5	11	15
Oklahoma	Tulsa	1 P.M.- 1 A.M.					8	16	29	41	71	92	120	140	161	200
Oregon	Portland	11 A.M.-11 P.M.												3	7	9
Penn.	Bellefonte	10 A.M.-10 P.M.														
	Pittsburgh	10 A.M.-10 P.M.													5	8
S. Carolina	Charleston	10 A.M.-10 P.M.											3	3	7	11
S. Dakota	Huron	1 P.M.- 1 A.M.			1	1	7	11	14	18	29	35	44	56	69	85
	Rapid City	Noon-Midnight								4	9	9	19	31	43	52
Tennessee	Knoxville	1 P.M.- 1 A.M.											4	4	5	9
	Memphis	1 P.M.- 1 A.M.								5	6	15	19	30	52	58
Texas	Amarillo	1 P.M.- 1 A.M.										5	10	13	26	58
	Brownsville	1 P.M.- 1 A.M.														
	Dallas	1 P.M.- 1 A.M.						3	8	15	23	49	77	112	168	227
	El Paso	Noon-Midnight										7	11	23	43	86
	Houston	1 P.M.- 1 A.M.											4	9	14	23
	San Antonio	1 P.M.- 1 A.M.									5	10	19	39	52	77
Utah	Modena	Noon-Midnight														4
	Salt Lake City	Noon-Midnight									6	10	22	36	42	58
Washington	Seattle	1 P.M.- 1 A.M.														
	Spokane	11 A.M.-11 P.M.					3	6	7	8	9	10	11	14	18	26
Wisconsin	Green Bay	1 P.M.- 1 A.M.												3	5	9
	La Crosse	1 P.M.- 1 A.M.											4	12	17	20
Wyoming	Rock Springs	Noon-Midnight														

*All readings of 2 hours or less have been omitted.
†Temperatures are in degrees Fahrenheit.

Courtesy of Marley Company

XUM



use AIRCO supplies for better welds

What do you need in the way of welding supplies, accessories and equipment? You name it — Airco has it at low prices. Call your Airco dealer or write us directly for your copies of our Electrode Catalog and Gas Supplies Catalog along with complete price lists.

Airco ferrous electrodes: For all types of steel — mild, low-alloy, stainless — and cast iron. Airco electrodes provide arc stability, smooth bead contour, easy slag removal and minimum spatter — that's why Airco is thought of first when welders want ease of operation and high production of quality welds. A complete line of AC and DC types answers all welding problems.

Airco non-ferrous electrodes: Save time and expense welding aluminum, aluminum bronze and manganese bronze, making machinable welds in cast iron, depositing bearing surfaces, build-ups of worn areas and other types of overlays.

Airco hardfacing alloys: Airco provides 26 rods to combat wear, abrasion, heat and corrosion. Hardness of deposits, with various alloys, from 17 to above 80 Rockwell C. If you have a maintenance problem involving wear or rapid deterioration of surfaces, end it with these hardfacing alloys. Some types available in wire form for submerged-melt application.

Airco gas welding rods: The logical choice for all oxyacetylene welding, brazing and braze-welding. Eight types — bare and coated low-fuming bronze rods, wear-resistant rods, manganese bronze and deoxidized copper. Diameters, in various types, from 1/16″ to 3/8″. All types and diameters in 36″ lengths.

Airco fluxes: There's an Airco flux for every welding, brazing and braze-welding job. Ten different fluxes, for brass, bronze, copper, stainless steel, aluminum, cast iron, malleable iron, and other metals and alloys.

Airco silver brazing alloys and fluxes: Airco offers you the complete line of famous "Easy-Flo" silver brazing alloys. The low flowing temperature of all these alloys saves labor, time and gases, and minimizes distortion. For all types of joints and all combinations of metals.

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AN AIR REDUCTION PRODUCT

at the frontiers of progress you'll find

Southwestern Headquarters for Oxygen, Acetylene and Other Gases . . . Carbide . . . Gas Welding and Cutting Machines, Apparatus and Supplies . . . Arc Welders, Electrodes and Accessories

ANALYSIS OF DRY BULB TEMPERATURES ON A TWELVE-HOUR BASIS

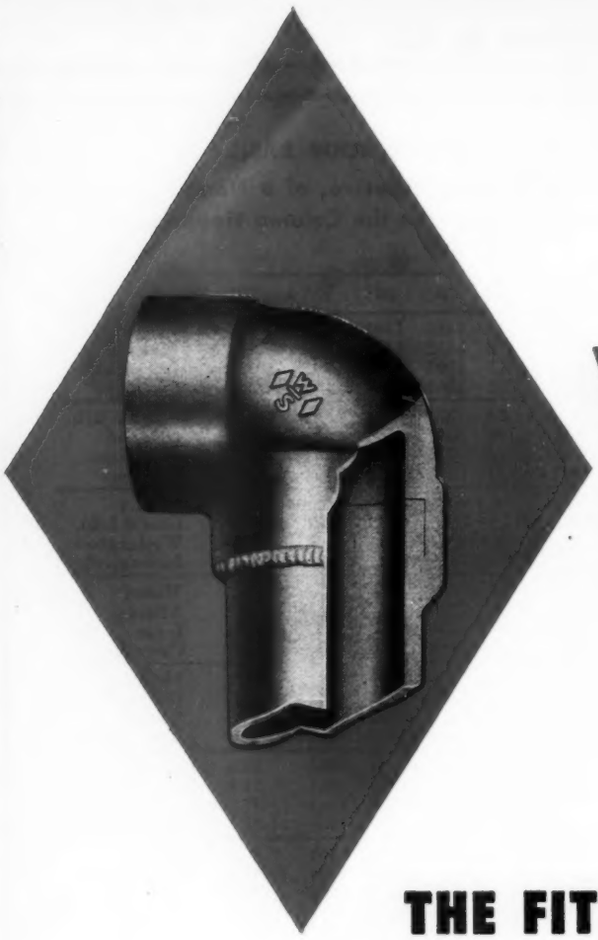
Number of Hours During Daily Periods Covered in June to September, Inclusive, of a Normal Year, That Dry Bulb Readings Will Equal or Exceed the Temperatures Shown in the Column Headings*†

96°	95°	94°	93°	92°	91°	90°	88°	86°	84°	82°	80°	75°	70°	60°	40°	Avg. Temp.	City
3	3	11	23	45	85	119	225	337	445	596	848	1301	1438	1461	1464	80.9	Mobile
747	792	831	865	911	959	1001	1059	1139	1197	1259	1316	1412	1452	1461	1461	93.9	Phoenix
61	77	101	140	195	236	300	443	549	647	765	923	1217	1395	1452	1461	82.2	Little Rock
442	482	536	576	616	640	690	766	838	912	992	1042	1232	1364	1461	1464	87.3	Fresno
										4	12	56	332	1362	1464	66.1	Laguna Bch.
		4	4	6	8	14	24	42	46	70	96	190	396	1162	1461	66.2	Oakland
							3	12	24	39	90	272	711	1445	1461	69.7	San Diego
351	395	441	486	541	585	639	725	814	921	997	1071	1238	1364	1455	1464	86.8	Williams
15	25	34	52	74	92	123	195	296	373	440	534	775	1048	1360	1460	75.3	Denver
73	106	144	187	235	297	353	461	571	681	814	936	1171	1286	1439	1461	82.0	Grand Jctn.
45	60	69	88	121	164	200	281	381	508	603	715	999	1221	1444	1464	79.0	Washington
41	60	97	140	197	269	363	553	704	835	990	1141	1385	1459	1464	1464	80.5	Jacksonville
				16	54	140	374	622	764	928	1178	1422	1464	1464	1464	83.6	Miami
39	53	82	103	126	159	208	279	355	468	580	708	1036	1329	1461	1464	79.6	Atlanta
91	118	143	171	210	251	284	381	460	551	635	706	869	1069	1337	1462	76.6	Boise
42	60	76	87	104	118	130	189	239	308	378	462	732	1018	1360	1464	71.9	Chicago
63	78	103	119	152	165	199	259	323	411	505	611	833	1095	1361	1464	76.6	Moline
42	56	74	98	142	170	208	264	374	470	590	686	958	1230	1434	1464	78.8	Evansville
337	365	412	441	481	532	587	665	745	821	924	988	1131	1268	1396	1464	84.6	Wichita
	4	17	40	80	132	203	325	448	577	729	900	1321	1447	1463	1464	81.9	New Orleans
124	161	210	273	334	411	485	596	715	826	934	1055	1272	1422	1464	1464	84.6	Shreveport
3	4	10	11	17	26	32	51	90	136	207	288	522	840	1390	1464	71.8	Boston
28	34	46	58	88	112	148	220	288	368	492	610	928	1206	1408	1464	77.3	Detroit
34	42	50	61	76	88	107	147	210	285	377	460	694	946	1304	1462	73.4	St. Paul
68	95	136	182	226	280	310	376	458	534	602	716	1080	1371	1449	1464	80.7	Jackson
209	243	269	300	322	366	418	513	613	728	832	921	1107	1282	1439	1464	82.8	Kansas City
124	147	168	180	205	231	254	332	407	492	570	646	880	1070	1333	1464	77.6	Kirksville
139	174	190	221	258	296	326	407	505	285	377	460	694	946	1304	1462	73.4	St. Louis
20	32	58	76	110	132	164	286	384	532	668	794	1116	1326	1456	1464	80.2	Springfield
12	20	20	24	28	44	56	108	176	224	288	384	560	804	1156	1464	70.0	Helena
101	121	149	187	231	261	304	405	480	560	648	723	940	1116	1355	1457	78.4	North Platte
136	171	216	237	260	296	339	432	527	611	716	820	1023	1209	1395	1463	80.4	Omaha
51	75	97	128	162	191	228	327	421	496	590	666	841	997	1291	1452	75.8	Elko
56	80	96	134	178	232	260	340	420	510	620	692	898	1068	1352	1460	77.3	Reno
14	24	32	40	62	76	108	146	194	262	350	460	736	1046	1390	1464	74.8	Camden
13	24	33	45	61	75	89	127	200	281	376	489	807	1149	1443	1464	76.1	Newark
24	40	75	113	163	211	261	376	481	605	740	821	1072	1257	1452	1464	80.4	Albuquerque
5	8	15	20	25	35	48	79	117	176	251	349	637	761	1347	1464	72.8	Albany
			6	16	18	26	48	74	106	168	226	466	738	1200	1464	69.2	Buffalo
18	25	33	39	57	71	86	126	207	302	401	541	894	1206	1446	1464	76.9	New York
21	35	61	89	118	150	189	324	473	627	755	897	1204	1380	1461	1464	81.5	Raleigh
		8	12	36	60	76	180	356	544	701	916	1240	1436	1464	1464	81.0	Wilmington
52	65	80	90	108	124	157	193	250	334	398	488	680	894	1238	1453	73.0	Fargo
57	78	94	124	154	182	221	311	435	579	701	824	1108	1322	1449	1461	80.7	Cincinnati
23	39	55	66	89	118	144	212	302	386	502	632	918	1187	1415	1464	77.4	Cleveland
229	276	317	367	400	428	480	579	687	800	923	1016	1241	1376	1449	1464	84.8	Tulsa
11	21	23	27	37	47	59	87	127	176	228	281	520	779	1339	1464	71.4	Portland
6	11	19	24	32	47	63	96	140	176	256	477	747	1067	1401	1464	73.8	Bellefonte
15	23	31	40	59	75	95	151	213	305	437	568	889	1156	1405	1464	76.4	Pittsburgh
15	24	41	54	86	120	189	318	455	567	687	804	874	1399	1463	1464	81.5	Charleston
96	109	128	147	174	196	227	279	347	427	510	580	804	1020	1328	1457	76.2	Huron
67	87	116	137	152	189	213	279	364	453	533	607	824	1015	1327	1449	75.8	Rapid City
15	24	39	57	87	120	152	235	325	456	580	707	1048	1304	1457	1461	78.9	Knoxville
78	90	126	158	193	234	285	405	502	608	746	863	1173	1346	1451	1464	81.7	Memphis
83	117	167	212	271	323	380	489	576	676	757	863	1096	1279	1445	1463	81.6	Amarillo
3	4	10	17	58	107	179	307	484	704	921	1136	1429	1464	1464	1464	83.3	Brownsville
291	361	437	492	548	609	680	793	920	1055	1155	1232	1384	1440	1464	1464	88.0	Dallas
155	206	265	349	413	488	566	681	788	891	1014	1114	1316	1432	1463	1464	85.7	El Paso
33	50	74	93	135	181	230	363	496	611	731	870	1278	1440	1464	1464	82.1	Houston
118	184	242	321	418	508	607	743	842	943	1055	1212	1406	1453	1464	1464	86.6	San Antonio
11	17	32	48	69	93	135	213	300	407	476	567	729	921	1245	1455	73.5	Modena
88	98	110	178	222	282	340	448	534	602	672	750	954	1170	1350	1456	78.9	Salt Lake City
								12	18	36	70	198	428	1092	1464	65.1	Seattle
39	46	57	74	99	112	155	216	271	337	432	501	721	957	1296	1461	74.2	Spokane
12	13	20	29	37	43	59	81	112	171	225	292	476	768	1241	1461	70.3	Green Bay
27	33	47	61	77	88	104	153	204	277	361	468	720	952	1303	1463	73.6	La Crosse
					6	20	42	102	168	266	364	626	914	1272	1454	71.6	Rock Springs

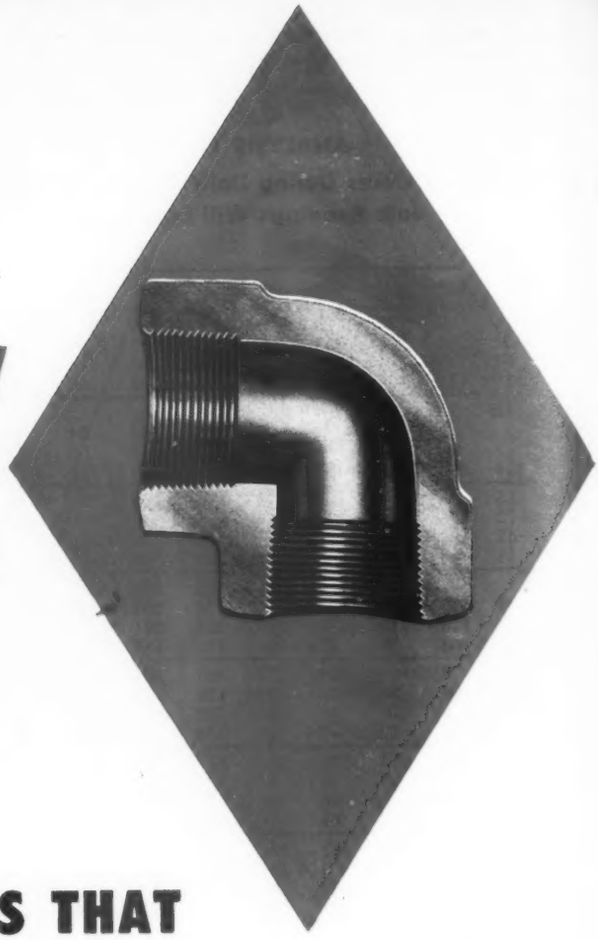
*All readings of 2 hours or less have been omitted.
†Temperatures are in degrees Fahrenheit.

Courtesy of Marley Company

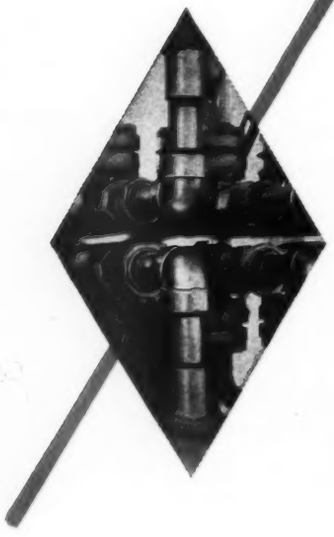
XUM



W-S



THE FITTINGS THAT CAN REALLY TAKE IT!



Every elbow, tee and cross in a high pressure piping system is a point of concentrated stress. W-S Forged Steel Fittings take this tough service in stride because they're fabricated and designed to resist pressure, heat, shock and vibration. They're drop forged of highest quality steel to produce a dense, tough, forged-fiber structure that can really take it. And careful heat treatment after forging develops the metallurgical properties of the steel to their fullest.

Notice, too, how Watson-Stillman engineers have designed extra strength into the fittings. Long bands extend well beyond the threads or sockets to provide extra reinforcement. Wall thickness is carefully calculated to put extra metal at points of severest stress.

W-S high-precision machining and rigorous inspection follow through to give you the fittings that mean stronger, tougher pipe joints. W-S Forged Steel Fittings are available in both Screw-End and Socket-Welding types in carbon, stainless and alloy steels.

Sold Through Leading Distributors

WATSON-STILLMAN FITTINGS DIVISION

H. K. PORTER COMPANY, INC.

Roselle, New Jersey

Dry-Bulb and Wet-Bulb Design Summer Temperatures for Various Applications in Typical U.S.A. Cities

State	City	Design Dry-bulb Temperature 60 hr. (2%)† deg. F.	Design Wet-bulb Temperatures			
			Critical Full-load Requirements 60 hr. (2%) † deg. F.	ACRMA* Recommendations, Air Conditioning 150 hr. (5%)† deg. F.	Steam Turbines, Diesel Engines; Full-load, Continuous. 600 hr. (20%) †	Steam Turbines, Diesel Engines; Partial-load, Intermittent. Refrigeration. 1000 hr. (35%) †
Alabama	Birmingham	95	79	78	76	75
	Mobile	95	80	80	77	76
	Montgomery	95	79	78	76	75
Arizona	Flagstaff	95	65	65	60	58
	Phoenix	108	78	76	72	71
	Tucson	105	73	72	70	67
	Yuma	110	79	78	74	72
Arkansas	Little Rock	97	80	78	76	75
California	Bakersfield	105	72	70	68	65
	El Centro	100	80	78	76	75
	Fresno	105	73	72	70	67
	Long Beach	92	72	70	67	64
	Los Angeles	92	72	70	67	64
	Needles	100	80	80	76	74
	Oakland	84	65	65	59	58
	Pasadena	92	72	70	67	64
	Sacramento	100	73	72	70	67
	San Bernardino	100	73	72	70	67
	San Diego	82	72	70	67	65
	San Francisco	84	65	65	59	58
Colorado	Denver	93	65	64	61	59
Connecticut	Bridgeport	95	77	75	70	67
	Hartford	95	77	75	69	67
	New Haven	95	77	75	70	67
Delaware	Wilmington	95	80	78	74	72
D. C.	Washington	96	80	78	74	72
Florida	Jacksonville	95	80	78	77	76
	Miami	91	80	79	78	77
	Pensacola	95	80	78	77	76
	Tampa	95	80	78	77	76
Georgia	Atlanta	95	79	76	74	72
	Augusta	95	79	76	74	72
	Brunswick	95	80	78	75	72
	Columbus	95	79	76	74	72
	Savannah	95	80	78	75	72
Idaho	Boise	98	67	65	61	58
Illinois	Chicago	96	77	75	70	67
	Peoria	97	78	76	72	69
Indiana	Evansville	96	78	76	72	70
	Fort Wayne	96	77	75	70	67
	Indianapolis	96	78	76	72	70
Iowa	Des Moines	95	78	77	72	70
	Sioux City	95	78	77	72	70
Kansas	Wichita	102	76	75	72	70
Kentucky	Louisville	98	80	78	75	72
Louisiana	New Orleans	93	81	79	78	77
	Shreveport	98	80	78	77	75
Maine	Augusta	88	73	73	67	62
	Bangor	88	73	73	67	62
	Portland	88	73	73	67	62
Maryland	Baltimore	97	80	78	74	72
	Cumberland	95	76	75	72	70

*"Application Engineering Standards for Air Conditioning for Comfort", Air Conditioning and Refrigerating Machinery Association, Inc., Washington, D. C.

†Temperatures listed will not be exceeded more than time indicated, June to Sept., incl.

NOTE: For installations in the center of large cities and in industrial areas, it is recommended that the design temperatures be about 2 degrees higher than the values listed.

Courtesy of Marley Company

XUM

OIL and GAS TRADE NEWS

New Firm in Houston

Morris-Young-Owens Company, a newly organized corporation in Houston, Texas, has made its entrance into the pipe line equipment and supply business, according to an announcement by officers of the company. Officers are: E. D. "Gene" Morris, president; Clarence L. Owens, vice president, and James L. Young, secretary and treasurer.

Morris, after serving 10 years with Humble Oil and Refining, resigned to enter the pipe line field in 1940. He was associated with Engineers, Ltd.; I. C. Little Construction, and O. C. Whitaker Contracting.

Young, after many years as general shop superintendent with one of the leading pipe line equipment and supply companies, resigned his position in 1953, to enter this new enterprise.

Owens has been associated with the pipe line industry for the last 15 years. He served as materials man for 8 years with several of the major pipe line construction companies, and has spent the last 7 years as service man for one of the larger equipment companies.

The new company manufactures line travel and stationary, counter rotating head, cleaning and priming machines, line travel and stationary coating and wrapping machines, all sizes asphalt kettles, ranging in sizes from 3 bbl patch pot to 17, 25, and 30 bbl double agitated dope pots, adjustable pipe cradles, and numerous other items for the pipeliner.

Republic Supply Is Agent

The Republic Steel Corporation has appointed The Republic Supply Company of California, as a West Coast distributor for its oil country tubular goods, and line pipe.

Glenn E. Pitts, oil field sales manager for The Republic Supply Company of California, is in charge of all oil country sales for his firm.

J. G. "Andy" Anderson will head the firm's inside pipe order department.

BS&B Appoints Distributors

Black, Sivalls & Bryson, Inc., announces the appointment of two new manufacturer's representatives for its line of automatic control equipment and safety heads.

Fluid Controls Company, Inc., will cover the District of Columbia and Maryland and Virginia, except the extreme western counties. Fred C. Hasselberg at Richmond, Virginia, and Benjamin Volker at Baltimore, are sales representatives for the company.

Berry Ervin Engineering Company, Minneapolis, Minnesota, will cover Minnesota, North Dakota, Eastern South Dakota, and Western Wisconsin. George W. Saver, owner, Carroll Cross and Berry Ervin will represent the company.

Gas Men to Judge Contest

Five gas and electric utility company executives have been chosen as judges in a $5000 essay contest being sponsored by Rockwell Manufacturing Company for persons employed in the gas industry. The five are: D. A. Hulcy, president, Lone Star Gas; F. A. Lydecker, vice president of gas operations, Public Service Electric and Gas Company; H. L. Masser, executive vice president, Southern California Gas; William G. Rogers, president, East Ohio Gas; H. Carl Wolf, managing director, American Gas Association. Winners will be in two catagories:

1. For an essay not exceeding 2000 words in length on the subject "The Economics of a Planned Meter Retirement Program."

2. For adding the last line of a jingle on the same theme.

Hyster Names Agency

Hyster Company has named Cole and Weber, Portland, Oregon, as its domestic-export advertising agency and marketing and public relations counsellors for both the tractor equipment and the industrial truck divisions of the company. Hyster Company operates four factories located in Portland, Oregon; Peoria and Danville, Illinois; and Nijmegen, The Netherlands.

New Representative Named

Lichtenberger Brothers of Chicago have been named distributors for Cleco Air Tools, it was announced by T. E. Donohue, sales manager for the Cleco Pneumatic Tool Division of Reed Roller Bit Company. Cleco manufactures the Cleco and Dallett lines of air powered tools and accessories.

Distilling Plant Complete

The Griscom-Russell Company in cooperation with Bethlehem Steel Company, has recently completed and shipped what is believed to be the largest flash type distilling plant built up to this time for producing fresh water from sea water. The unit now goes to Bethlehem Quincy Yard for outfitting and the customary testing, subsequent to which it will be shipped to the U. S. Navy.

Mission Manfacturing Company has recently held divisional sales meetings in Odessa, Oklahoma City, Baton Rouge, and at Camp Mission at Aransas Pass for their salesmen in the field. At Aransas Pass (No. 1) were: W. C. Underwood, G. B. Wyatt, F. J. Hebert, F. S. Mims, J. S. Stewart, Jack Bannister, and Tony Volotko.
At Odessa (No. 2): Standing, L. L. Roberson, R. E. Hardy T. R. Fullinwider, E. D. Hallum. Seated, L. M. Roberson, O. K. Ryan, John Bannister, and W. T. Campbell.
At Baton Rouge (No.3): Standing, A. E. Higginbotham, Campbell, Fullinwider. Seated, C. L. Turner, and Joe Scalise.
At Oklahoma City (No. 4): Standing, Fullinwider, R. M. Wood, G. G. Boyd, C. W. Fryar, M. C. Davis, Campbell. Seated, George DeArman, J. E. Young, E. L. Brown, and J. H. Brown.

Raleigh Hortenstine, Jr., division manager, Continental Supply, and H. H. Peters, president, Technical Oil Tool, at Continental's 14th annual sales meeting. Center, H. E. Lowrey, manager Venezuelan operations, Continental, talks with J. A. Conlon, vice president, New York Belting and Packing; and L. R. Murray, export representative, Julio Zumeta, executive manager of exports, and D. M. Bailey, vice president and general counsel, Continental. At right is Frank I. Brinegar, executive vice president, Continental, and J. L. Mauthe, president, Youngstown Sheet and Tube. Headquarters for meeting were in the Baker Hotel, Dallas.

Aggressive Selling and Better Service — Continental's Motto

Supply company has 14th annual sales meeting in Dallas, Texas

Theme of Continental Supply Company's 14th annual sales meeting, recently held in Dallas, Texas, was "agressive selling" and continuing improvement of service. One of the mornings' sessions were conducted by representatives of Continental's associated manufacturers, and balance of the meeting was a series of panel discussions for Continental representatives. Attendin were 260 Continental field men and Dallas office men and representatives from associated companies.

Among associated companies' officials present were, J. L. Mauthe, president, Youngstown Sheet and Tube. Other leading petroleum equipment men participating in the meeting were: J. H. Bascom, executive vice president, Broderick & Bascom Rope; Brinton Welser, vice president, Chain Belt; T. Bruce Cox, manager union sales, Clayton Mark and Company; W. T. Powell, president, Emsco; J. V. Leece, vice president, Gardner-Denver; J. F. Hacker, vice president, Ladish; Paul M. Arnall, president, Lunkenheimer; Bob Snyder, vice president, New Bedford Cordage; Joe A. Conlon, vice president, New York Belting and Packing; Roy Bush, Nordstorm Valves, Rockwell, and H. H. Peters, president Totco.

Outstanding social event was the annual 25-Year Club reception and dinner. Noble A. Endicott was elected president for 1954. Charles H. Fischer, Evansville, Indiana, and Ralph R. Lewis, Dallas, were presented 40-year pins during the dinner.

Frank I. Brinegar, executive vice president, extended the welcoming message and presided over the several meetings.

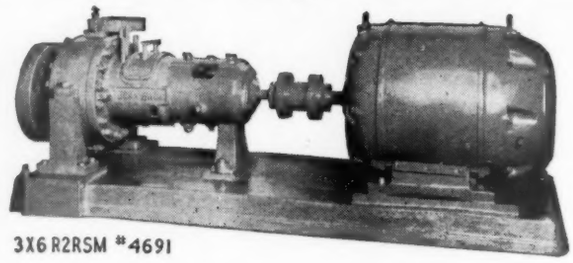
W. C. Kinder, vice president, Emsco Manufacturing, and Allen Whitesides, manager, drilling division, Continental.

R. J. Bauer, division manager, Gardner Denver, and Jack Mussler, general manager of sales, Continental, look at company motto for 1954. Center, Bob Snyder, vice president, New Bedford Company, N. A. Endicott, vice president, Continental. At right, D. M. Bailey, vice president and general counsel, Continental, with L. E. Wallace, assistant vice president, Youngstown Sheet and Tube, and W. C. Kinder, vice president, Emsco Manufacturing. Guests at the meeting were from associated companies.

XUM

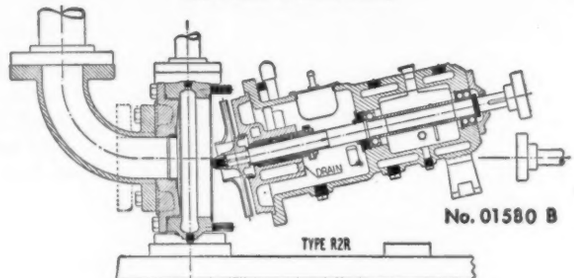
DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



3X6 R2RSM #4691

Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

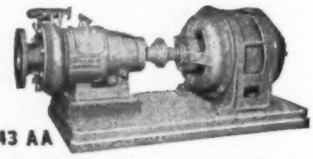
OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. **Speeds:** 900 RPM to 4000 RPM.

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

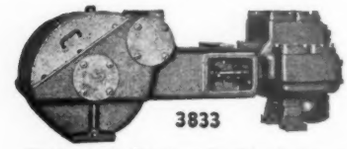
CENTRIFUGAL AND RECIPROCATING PUMPS

4040H
Close Coupled Centrifugal Pump

3510
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids



4043 AA
Pedestal Mounted Centrifugal Pump



3833
Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump

4728
Double Pedestal Bearing Centrifugal Pump

3556
Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

323 W TENTH ST.

Branch Offices: NEW YORK, N. Y., HOUSTON, TEXAS

Representatives in Principal Cities

Trade News

Buy Manufacturing Rights

Davey Compressor Company has purchased all manufacturing rights to the complete line of portable rotary drilling units previously produced by Engineering Laboratories, Inc., Garland, Texas. An announcement, issued by J. T. Myers, Davey vice president, stated that transfer of all engineering laboratories operations to Kent is now underway and that delivery schedules will be rigidly maintained. The purchase included the complete inventory of finished drill units and service parts, according to Myers.

Drill unit manufacturing operations at Kent will be handled by a newly-established Davey Rotary Drill Division.

Lufkin-Lacy Agreement

The Lufkin Foundry and Machine Company, Lufkin, Texas, announces an arrangement with Lacy Oil Tool Company, Los Angeles, California, whereby they acquire sole rights for the manufacture, sale, distribution, and servicing of air-balanced pumping units through the entire oil world, with the exception of California. Lacy Oil Tool Company will merchandise their air-balanced unit in the state of California only.

Totco Division Formed

H. H. "Pete" Peters, president, Technical Oil Tool Corporation, announced that the Totco service organization in Oklahoma and Kansas has been designated a division and placed under the direction of R. W. "Bo" Ard, who was named division manager. Ard, with Totco since 1949, will operate from headquarters in Oklahoma City. To increase the effectiveness of Totco service near Oklahoma City, James R. Acton was added to the Totco staff. Acton was formerly employed by an Oklahoma City supply store.

Foxboro Factory Nears Completion in Dallas

A new branch factory, now being built, will double the Dallas, Texas, facilities of The Foxboro Company. The expansion reflects the growing demand for instrumentation by the region's industrial users, especially in the petroleum refining, natural gas, chemical, and petrochemical fields. Scheduled for occupancy on April 30, the new building will provide 13,000 sq ft of space. The new plant is of modern brick construction, designed on a single level for maximum efficiency.

Dresser Selects Tulsa Site

The signing of a purchase agreement with Industrial Sites, Inc., of Tulsa, Oklahoma, has cleared the way for further expansion by Dresser Industries, Inc., of Dallas, Texas, in the Tulsa area.

Consummation of the agreement and the start of a long-range program involving an ultimate capital expenditure of more than a million dollars has been jointly announced by J. B. O'Connor, executive vice president of Dresser Industries, Inc., and Ray H. and Robert M. Siegfried, owners of Industrial Sites, Inc., of Tulsa, developers of the New Sheridan industrial district in that city.

As soon as present lease commitments expire, the other Dresser subsidiaries will be relocated at the new Tulsa site. One of these is Pacific Pumps, Inc., of Huntington Park, California.

Future plans call for other Dresser operating companies to be moved to the new Tulsa location, which will eventually house a representative group of the firm's member companies.

Carter Announces Agents

S. C. Carter Company, Inc., announces the appointment of Wilson Supply Company as distributors for Arkansas and Louisiana. Wilson Supply Company, which already distributes Carter units in South Texas, will handle sales and service in its new territory from its offices at Harvery, Houma, Lake Charles, New Iberia, and Shreveport. Don C. Lawrence of Wilson Supply has been designated to handle the Carter line with headquarters at Shreveport.

Price Drop Reported

A price reduction on vinyltoluene has been announced by Donald L. Gibb, manager of the plastics sales department, The Dow Chemical Company. Tank-car price of the new monomer will be 19 cents per pound, F.O.B. Midland, Michigan, a price drop of almost two cents per pound. The same reduction has been made on other quantities.

Blaw-Knox Sales Up in 1953

Sales of Blaw-Knox Company reached $120,591,000 last year, an increase of 20 per cent over the previous year's sales of $100,478,000, according to the company's annual report.

Reflecting higher sales, income from operations rose to $15,868,000, an increase of $4,272,000 over the $11,596,000 earned a year ago. This increase, however, was offset by a rise of $4,323,000 in charges for Federal income taxes and renegotiation. Net income, as a result, showed little change from 1952, amounting to $4,138,000 last year, compared with $4,189,000 the previous year.

First Anniversary Noted

Hill and Christopher, Los Angeles advertising agency, marked the first anniversary of their offices in the Halliburton Building, Los Angeles, California, recently, by offering to buy coffee for more than one thousand workers in the Halliburton Building. A note explaining why Hill and Christopher was "sponsoring" coffee was distributed to all offices in the 11-story building during early morning hours.

New Distributor Named

Appointment of Southern Engine and Pump Company, as distributor for peerless vertical and horizontal pumps in Southern Louisiana and southern part of Mississippi has been announced by Peerless Pump Division. Peerless pumps will be sold and serviced through Southern Engine and Pump Company branches located at Lafayette and New Orleans, Louisiana.

Proposed Merger Announced

Announcement has been made by Wright W. Gary, president, Attapulgus Minerals and Chemicals Corporation, and James Deshler, president, Edgar Brothers Company, that a basis of merger of the two companies has been agreed upon, subject to ratification by directors and stockholders. The merged company would be known as American Minerals and Chemicals Corporation.

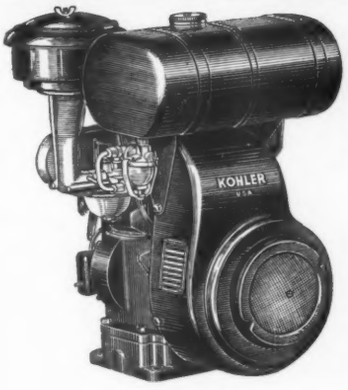
Attapulgus is largest producer in this country of fullers earth used widely in the chemical, petroleum, and other industries. Edgar Brothers is the oldest and one of the largest integrated producers of kaolin, a basic raw material used in the production of high-grade papers, wallpapers, and paperboard.

Sargent Engineering Corporation group, which met in Los Angeles to discuss expansion recently, included: Front row: Haskel F. Wright, Tulsa; Verdi E. Boyer, southern district California; L. H. Baher, California sales manager. Back row: G. L. Sargent, treasurer and general sales manager; J. H. Parker, Huntington Park; H. L. Sargent, assistant general sales manager; J. A. Laffin, Calif., O. H. Leichliter, Mid-Continent.

KOHLER ENGINES

4-CYCLE
AIR-COOLED

K90



K160

K90	3.6 H.P.
K160	6.6 H.P.
K330	12.0 H.P.
K660	26.8 H.P.

Kohler Engines are engineered and manufactured to the high standards which have made the Kohler mark known for quality the world over.

Power for garden tractors, pumps, sprayers, snow removal equipment, grain elevators, hoists, portable saws, concrete mixers, compressors, industrial lift trucks.

Write for information

K330

K660

Kohler Co., Kohler, Wisconsin
Established 1873

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS
AIR-COOLED ENGINES • PRECISION CONTROLS

HOSPITALITY AT ITS BEST IN HOUSTON

One thousand air-conditioned rooms... four great restaurants... 1,000-car garage ...ideal entertainment and convention facilities. Rates from $4.50 single and $6.50 double.

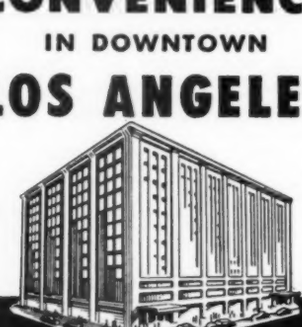
B. F. ORR, *Management*

RICE HOTEL

HOUSTON, TEXAS

Home of the fabulous Petroleum Club

CENTER OF CONVENIENCE IN DOWNTOWN LOS ANGELES



HOTEL CLARK

426 SOUTH HILL STREET

555 BEAUTIFUL ROOMS ALL WITH BATH

—FROM $3.50

- *Coffee Shop*
- *Dining Room*
- *Cocktail Lounge*

One-half block from new Pershing Square Garage

TRADE PERSONALS

A. M. Riddle has been appointed executive assistant to the president of The Colorado Fuel and Iron Corporation. As manager of the corporation's market research department, a position he has held since 1942, Riddle has worked closely with administrative, sales, and operating personnel. He has been with CF&I more than 30 years.

J. E. Brown

James E. Brown, treasurer of The Cooper-Bessemer Corporation, has been appointed to serve on the "Money and Credit Committee" of the National Association of Manufacturers. NAM's new Credit Committee has been organized to study significance of money and credit policies for the smooth functioning of private economy and avoidance of inflation and deflation.

O. S. Leslie, vice president in charge of manufacturing of Fairbanks Morse and Company, was elected to the board of directors. **J. A. Cuneo** who has for the past several years been general sales manager of the company, was elected vice president in charge of sales, and **Robert B. Craig,** formerly assistant to the president, was elected a vice president with his headquarters in Washington, D. C. Cuneo joined Fairbanks-Morse in 1929.

Mario A. Gasque has been named general manager of Fairbanks, Morse de Mexico S.A., and Manufacturera Fairbanks, Morse S.A. with offices in Mexico City and Tlalnepantla. Gasque joined the company in Mexico in 1946 as chief accountant. He succeeds **Paul A. Suess** who has been transferred to the company's Los Angeles branch as manager. **Alfred M. McLaren,** who has been manager of the Los Angeles branch, has been transferred to St. Louis to take over the company's branch house operations in that area, succeeding **Cliff Schroeer** who passed away recently.

John W. Spoor has been appointed to the newly-created post of assistant division manager of the welding products division of the A. O. Smith Corporation. He is succeeded as general sales manager by **Richard W. Raney.**

Spoor came to A. O. Smith in 1948 from the Brunswick-Balke-Collender Company. Formerly vice president in charge of sales for Arms-Franklin Corporation, Raney came to A. O. Smith in 1952. **Erv A. Steidl,** who was sales representative for A. O. Smith in the Middle West, now is the welding products division's sales engineer for Wisconsin.

Jim C. Orchard and **Frank Jones** have been added to the Nocor sales force by Cardinal Chemical, Inc., of Odessa, Texas. Orchard is a former student at Texas A & I. Prior to joining Nocor, he was office manager of the Famoso branch, Roscoe Moss Company, steel fabricators of Los Angeles. Jones studied at the University of California at Berkeley, and for the past year has been at Odessa as sales representative of Pacific Pumps, Inc.

Don Dye, L. E. (Sam) Johnson, and **W. R. Forcum,** have been named sales representatives of Harbison-Fischer Manufacturing Company.

Dye will represent the company in its Houston territory.

Johnson's headquarters will be in Midland, Texas. Forcum will work out of Denver.

Grover H. Huffhines has been appointed sales representative for the Wheland Company. He is a graduate of Texas A & M College and has been associated with major supply companies since 1936.

New Trane sales office appointments throughout the U. S. were announced recently by Thomas Hancock, vice president in charge of sales for The Trane Company. They are recent college graduates who have completed the first six months of the firm's Graduate Training Program. Assignments are:

William M. Baker, Ohio State University, to Canton; **James H. Bennett,** North Carolina State, to Greensboro; **Harry N. Casto,** West Virginia University, to Clarksburg; **Richard L. Clements,** Alabama Polytechnical Institute, to Atlanta; **Tyler G. Hegenwald,** University of Alabama, to New Orleans, Louisiana.

William P. Hutchins, North Carolina State, to Richmond, Virginia; **Donald Luallin,** University of Washington, to Seattle; **Chester Milligan,** Northeastern University, to Buffalo, New York; **William E. Nero,** University of Washington, to Los Angeles; **Amos L. Roberts, Jr.,** MIT, and Kansas University Business School, to Kansas City, Missouri. **John Sirois,** Dartmouth and Thayer School of Engineering, to Cleveland, Ohio; **James G. Tuten, Jr.,** Georgia Tech. to Knoxville.

Trane graduates assigned to La Crosse sales departments include:

Jim Hayes, Yale, to refrigeration sales; **Don Jaekle,** Yale, to heat transfer sales, and **Bill Myers,** Purdue, to products engineering.

Foreign 1954 Trane graduates are **Maqbool H. A. Taqui,** Bombay, India, and **Shanti A. Shah,** Gjuerat, India, both of whom will be employed by the American Refrigerator Company in Calcutta.

D. S. Harper, Jack Henderson, and **J. R. Tremblay** will represent Trane Company of Canada, Ltd.

Bob Lorentzen

R. A. Lorentzen has been named supervisor of Fluid Packed Pump Company's catalog and pricing section of the sales department. Lorentzen joined Fluid Packed Pump in 1937 as a plant worker. He was employed as shop inspector for 3 years. Lorentzen joined the engineering department of Fluid Packed Pump in 1950.

Sam A. Tener has been named to the staff of Hercules Tool Company. He will serve as sales representative in Oklahoma, Panhandle of Texas, and Wichita Falls, in the Texas area.

Trade Personals

R. M. Hammes has been appointed assistant general sales manager in charge of the Niagara filters division and the Tolhurst centrifugals division of American Machine and Metals, Inc. Hammes joined the company in 1943 as director of its training program. In 1946, he became assistant to the general sales manager in charge of sales promotion.

Gordon B. Hanson, president and chief engineer of Howe-Baker Company, has just returned from a six-weeks tour of Europe. He visited Holland, England, France, and Germany to look over several Howe-Baker desalting equipment installations now in use in Europe and installed additional new units.

George Miller, president of Oil Base, Inc., recently flew to Peru for a 2-month business trip through South America. He plans to confer with **Stan Parfet** and **Guido De Rossi** who heads up Servicios Petroleros S.A. of Lima, representatives drilling fluids and additives manufactured by Oil Base.

John E. Scoggan has been named assistant sales manager of C. Lee Cook Manufacturing Company. Scoggan formerly was in the firm's engineering and production control departments. In the latter department, he was production manager. He was formerly with Curtiss Wright.

Howard J. Klossner has been named chairman of the board, Standard Pipeprotection Inc. Other officers named are: **Hugh W. Baird,** president; **Henry W. Vondrasek,** vice president in charge of operations, and **J. B. Wilson,** secretary and treasurer.

Baird was graduated from Miami University, and his early training was with the United States Steel Corporation. He became vice president of Standard Pipeprotection, when it was founded in 1948. Vondrasek joined Standard Pipeprotection in 1948. Wilson has been secretary and treasurer of the company since 1948.

Maurice Webb of Houma, Louisiana, has been added to the Technical Oil Tool Corporation service organization in the South Louisiana district. Webb will cover the Harvey, Houma, and New Iberia, Louisiana, area for Totco. On the Texas Gulf Coast, **R. L. Kilgore** of Victoria, Texas, was employed to service the Victoria, Refugio, and El Campo, Texas area. Kilgore earlier worked for the Magnolia Petroleum Company.

M. P. O'Haver, formerly Rocky Mountain district superintendent of Lane-Wells Company, has been appointed assistant division operating superintendent of the Mid-Continent division and transferred from Casper, Wyoming to Oklahoma City. **J. F. Alexander,** formerly assistant to the division operating superintendent of the Mid-Continent division, will succeed O'Haver. **Donald R. Kirchner,** formerly gun perforator operator at Perry, Oklahoma, has been appointed district sales engineer trainee at Russell, Kansas.

Leonard J. Platt, industrial relations and personnel executive, has been appointed personnel manager of Lane-Wells Company. He will be in Los Angeles.

Arthur W. Gulliver has been appointed to Dravo Corporation's New York office staff as application engineer to handle the sale of fabricated piping. Prior to joining Dravo, he was sales engineer for Walsh-Holyoke Fabricators, Inc.

DURAMETALLIC *Packings*

Write today for FILE No. DMPE describing the complete line of Durametallic wear-free packings.

Product of

DURAMETALLIC CORP., KALAMAZOO, MICH.

Also manufacturers of rotary mechanical seals, oil pressure systems and packing tools.

The PELICAN

THE *Lowest* PRICED TWO-INCH PUMP OF ITS CAPACITY ON THE MARKET

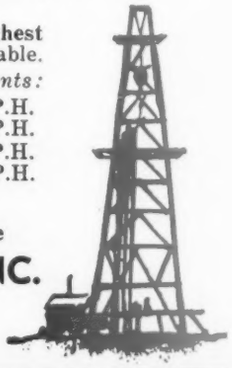
Gorman-Rupp self-priming centrifugal pumps are especially designed to meet the toughest requirements. The Pelican has many useful applications around a lease and -- it challenges any pump its size and type to equal its performance -- it never quits.

Gorman-Rupp pumps are the **Quickest Priming, Highest Priming, Fastest Pumping** and **Most Reliable** pumps available.

There's a choice of four lightweights for any requirements:

The Midget 1½"	Weight 62 lbs. . . .	5500 G.P.H.
The Pelican 2"	Weight 70 lbs. . . .	7500 G.P.H.
The Hawk 2"	Weight 110 lbs. . . .	10,000 G.P.H.
The Eagle 3"	Weight 117 lbs. . . .	18,000 G.P.H.

Ask for Bulletin No. 7-LW-13



Mid-Continent and Gulf Coast Oilfield Representative

HENRY H. PARIS DISTRIBUTOR, INC.

1125 Rothwell Street, Houston, Texas

A COMPLETE LINE OF CENTRIFUGALS IS AVAILABLE UP TO 240,000 G.P.H. CAPACITY.

THE GORMAN-RUPP COMPANY

MANSFIELD, OHIO

To obtain more information on products advertised see page E-57

Trade Personals

Hugh Glen has been elected president of Johnston Pump Company. He succeeds **Mrs. Thomas W. Simmons** who has resigned as president, but is still sole owner of the firm. Glen was formerly president of Emsco Derrick and Equipment Company.

Paul G. Tomalin, marine engineer, has been appointed by The Maxim Silencer Company to head its new Washington office. Tomalin will be responsible for sales and engineering of all Maxim products in the District of Columbia, Maryland, and Virginia. Tomalin started his marine career by serving on the New York State School Ship "Newport," graduating in 1924. He formerly taught marine engineering and naval architecture at George Washington University.

D. E. Whittenberg

H. L. Brown

B. F. Krause

V. B. Scott

D. E. Whittenberg of Houston and **Harold L. Brown** of Dallas, Texas, have been elected vice presidents of Garrett Oil Tools, Inc., and have also been appointed managers of sales in two recently created company sales regions. Whittenberg, formerly manager of the company's Southwest Texas division, was placed in charge of the Southern region from New Orleans, Louisiana to the Rio Grande River in Texas. Brown is manager of the Northern region, which includes East, North, and West Texas, North Louisiana, Arkansas, and Oklahoma.

B. F. Krause, former manager of the Texas Gulf Coast division, was made manager of the company's export division.

Vernon B. Scott, formerly manager of the distributing agency for Garrett relief valves, was named manager of the relief valve division.

W. J. Matson has been appointed sales engineer assigned to the McCullough Tool Company's Magnolia, Arkansas, branch. Matson's previous oil field experience includes eight years with Woodley Petroleum, six years with the Cavins Corporation — two of these years as district manager.

R. H. (Dick) Reynolds has recently been appointed manager of the Southern Engine and Pump Company. He is a graduate of the University of Houston. He joined Southern Engine and Pump in 1952 and served with the Houston office in the engineering department prior to transfer to Lafayette, Louisiana.

Arnol I. Sellars, former assistant chief engineer of Maloney-Crawford Tank and Manufacturing Company, has been appointed chief engineer. Sellars replaces **Sam Wilson,** who has resigned. He obtained his schooling at the University of Tulsa.

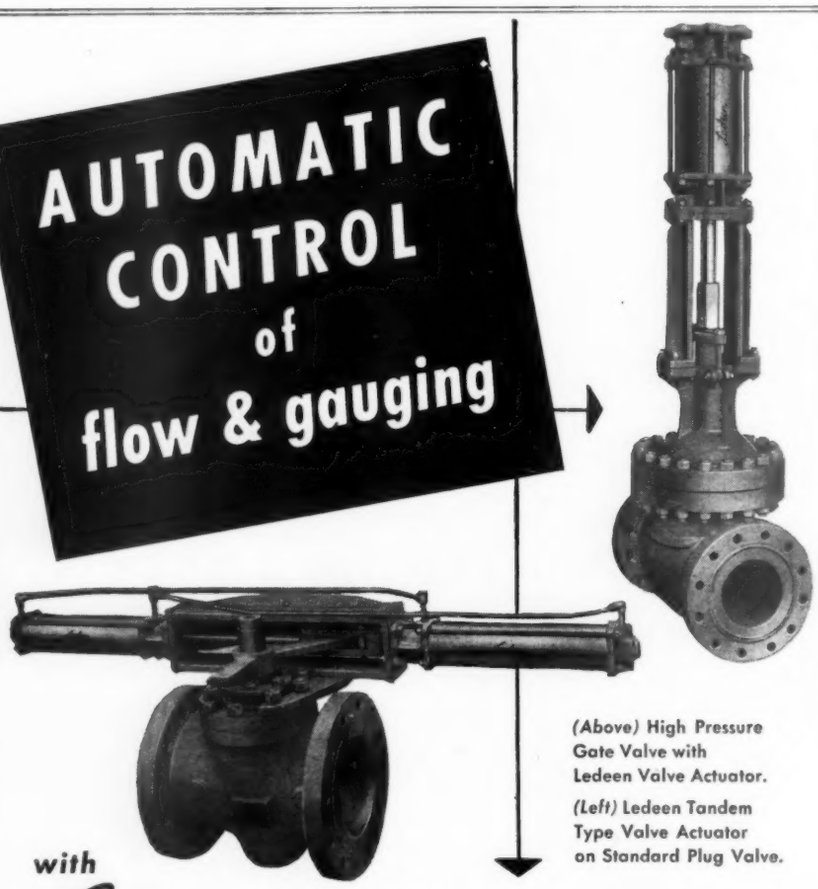
Arnol I. Sellars

George R. Birkelund, president of Baker, Fentress and Company, **Percy W. Bowers,** executive vice president of Flexonics Corporation of Canada, Ltd., and **Thomas K. Wells,** general sales manager of Flexonics Corporation, have been elected directors of Flexonics. The action increases the size of the board from three to six.

William M. Raynor has been named assistant to L. G. Bliss, vice president in charge of sales, Foote Mineral Company. In addition to his new responsibilities, he will continue as manager of special products sales for Foote.

Marvin W. Brandau has been promoted from industrial sales manager, Aeroquip Corporation, to director of market development. Brandau joined Aeroquip in 1940 and has held various executive positions since that time. **W. F. Rogge** replaces Brandau as industrial sales manager. Rogge was formerly general sales manager of World Bestos division, Firestone Tire and Rubber Company.

AUTOMATIC CONTROL of flow & gauging



(Above) High Pressure Gate Valve with Ledeen Valve Actuator.

(Left) Ledeen Tandem Type Valve Actuator on Standard Plug Valve.

with Ledeen VALVE ACTUATORS

★ Simple, Rugged Construction.
★ Few Moving Parts.
★ Easily Installed.
★ Prompt Delivery.

These actuators are for the automatic operation of gate, diaphragm, plug and other line valves, and are pneumatically or hydraulically operated for direct or remote control. Designed as package units, they are mounted directly on the valves without need of special manifolds or outside supports. They are easily, quickly and rigidly installed on new valves or on valves in service.

Ledeen Valve Actuators provide positive operation, permit automatic processing, safety installations, multiple central control ,and require a minimum of maintenance. WRITE FOR BULLETIN 3000.

VALVES • CYLINDERS
VALVE ACTUATORS
AIR HYDRAULIC
PUMPS & BOOSTERS

Ledeen Mfg. Co.
1608 SAN PEDRO
LOS ANGELES 15, CALIFORNIA

William G. Gray has been appointed manager of railway sales for the Pyle-National Company. Gray was formerly associated with various railroads throughout the country, as well as with the Pittsburgh Steel, and Union Asbestos and Rubber.

Carl O. Friend, formerly manager, gasoline marine engine department, Nordberg Manufacturing Company, is appointed administrative manager, heavy machinery division. He is succeeded by

Friend

Dow

McCarthy

Harrison E. Fellows, Jr., assistant sales manager of this department since 1952. **H. W. Dow, Jr.,** formerly mid-eastern district manager, is named chief sales technician, heavy machinery division.

In 1948 Friend was named manager of advertising, publicity, and sales promotion activities for the company. He retained this position until 1950 when he was appointed manager, gasoline marine engine department.

Dow, as chief sales technician, will primarily coordinate sales with the engineering, contract, and production departments in addition to handling special sales assignments.

Richard H. "Dick" McCarthy has been named sales engineer, Nordberg. He will have headquarters at Nordberg's branch office, Dallas, Texas.

In 1951 McCarthy joined Nordberg at Milwaukee after graduation from Oklahoma A & M.

C. E. (Todd) Lightfoot has joined The Lummus Company. For the past 25 years he has been active in the chemical industry, in chemical economics, sales, marketing, and consulting.

W. A. Schlueter

W. A. Schlueter has been appointed dealer in the southwest for products of the research and control instruments division, North American Philips Company, Inc. The new organization will be known as the Southwestern Electronics Corporation and will occupy a new building at 3920 South Peoria Avenue in Tulsa.

Schlueter established the Refinery Supply Company in Tulsa in 1918. Since the beginning, he has served as president of Refinery Supply Company, and subsidiary, resigning as chairman of the board recently.

Donald Hampton and **Mrs. Hazel Parker** will be members of the Tulsa staff.

Ray Loper has joined the staff of The Western Company, as operations training coordinator. Loper has worked closely with Western during the last three years on a consulting basis. He received his degree in petroleum engineering from Oklahoma University, where he taught for two years. He also taught petroleum engineering at Louisiana State University.

Joseph R. Roberts has been named advertising manager by Aeroquip Corporation. Roberts joined Aeroquip after serving with the International Harvester Company in Chicago where he was supervisor of industrial power advertising and sales promotion. He attended Crane Junior College, and Northwestern University School of Commerce.

A. S. Kromer has been named vice president of Calumet and Hecla, Inc., and general manager of the firm's Calumet division, with headquarters in Calumet, Michigan. He has been with the company since 1935, when he began in the Detroit plant of the Wolverine Tube. In Calumet Kromer succeeds **Orson A. Rockwell,** who has resigned to become an executive of Eagle-Picher Company.

Neal B. LauBach, Hudson Engineering Corporation, has been elected president of the Cooling Tower Institute. Other new officers are: **Paul R. Hoffmann,** Lilic-Hoffmann Cooling Towers, Inc., vice president; **Clayton E. Pickup,** Fluor, secretary; and **Robert R. Pabodie,** United Cooling Tower, treasurer. President for the 1953 term was **Leon T. Mart** of The Marley Company.

C. D. (Don) La Susa has been appointed to the newly created position of petroleum, technical service, for the Armour chemical division's fat-derived products. His primary responsibility will be to assist primary and secondary oil producers, refiners, and processors, in solving corrosion and bacteria-algae growth problems common to the industry.

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Chicago, Ill.—Harry A. Jay, Suite 1090, Old Colony Bldg.
Denver, Colo.—Earl H. Jones & Co., 1863 Wazee St.
Detroit, Mich.—Thomas L. Osberger, 10226 Woodward Ave.
Erie, Pa.—R. J. Maggi, Box 711
Falmouth, Mass.—Walter S. Bennett, 53 Minot St.
Ferguson, Mo.—Wm. H. Heckenberg, 635 No. Florissant Rd.
Houston, Tex.—Henry H. Paris Distributor, Inc., Box 932
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Ave.
Minneapolis, Minn.—Lin J. Krause, 200 Lumber Exchange
Narberth, Pa.—J. W. Worthington, 105 Forrest Ave.
New York, N. Y.—Henry Stein, 50 Cliff St.
Portland, Ore.—Earl H. Jones & Co., 1233 NW 12th Ave.
Richmond, Va.—P. C. Abbott & Co., 15 E. Franklin St.
San Francisco, Cal.—Earl H. Jones & Co., 1150 Folsom St.
Seattle, Wash.—Earl H. Jones & Co., 819 Thomas St.
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New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) FLOW TUBE

Builders-Providence, Inc., division of B-I-F Industries, Inc., has announced a new device known as the Dall flow tube for metering liquids and gases. It is designed for use with gases and liquids carrying no settleable solids. It consists of a short, flanged, cylindrical body designed with an abrupt decrease in diameter, followed by a conical restriction and diverging outlet. Reduced area at the cone entrance together with the design of the annular throat induces high differential pressure obtained.

Circle letter (A) on reply card.

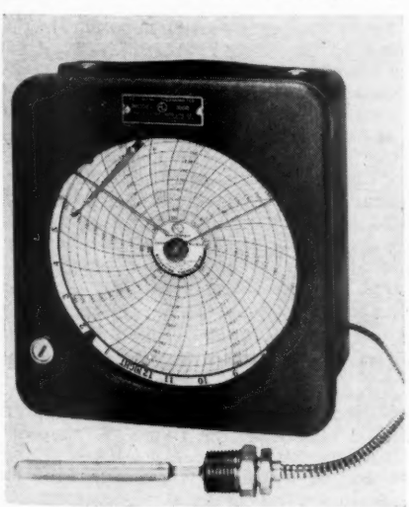
(B) METERS

The Model 34 direct reading Fann V-G meter offers a new concept of the field measurement of drilling fluids. From a single dial, the two components that make up apparent vicosity are separated, evaluated, and gel strength determined. These values are in absolute units. Apparent viscosity, the value obtained by a conventional single speed instrument, is composed of two properties: Yield point and plastic viscosity, each acting independently to affect flow. This new direct reading V-G meter measures these properties accurately; only a simple calculation is required.

Circle letter (B) on reply card.

(C) TEMPERATURE RECORDER

A new temperature recorder, Model "1000," with a 6-in., clear reading, evenly-calibrated chart has been developed by

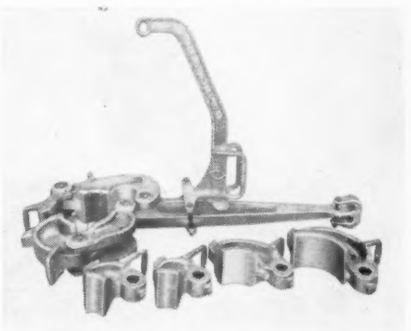


The Electric Auto-Lite Company. It is available with 24-hour (one chart revolution daily) or 7-day (one chart revolution weekly) electric or mechanical chart drive. Standard chart ranges between 40 deg to plus 550 F.

Circle letter (C) on reply card.

(D) TOOL JOINTS

A new type "H" tong has been designed to break out the largest and tightest drill collars or tool joints with safety possible by Web Wilson Oil Tools, Inc. It em-



bodies all features of convenience and easy operation present in other Web Wilson tongs, with such features as 2-in. diameter hinge pins; 30 per cent greater strength, with only 15 per cent increase in weight; ring retainers at both ends of each 2-in. hinge pin.

Circle letter (D) on reply card.

(E) THREAD COMPOUND

A new high temperature thread compound that protects against the welding action of threaded connections subjected to prolonged exposure to extreme heat has been developed by Crane Packing Company. Known as "Thred-Gard" it is said to eliminate seizing and galling at operating temperatures up to 1200 F. The compound is non-hardening and acts as a lubricant to allow easy dis-assembly of threaded connections.

Circle letter (E) on reply card.

(F) PROPORTIONING PUMP

Proportioneers, Inc., announces new models and improvements in the design of its 1105-S proportioning pump introduced a year ago. Originally available only as a 10-gal per hour pump with one motor voltage, the 1105-S is now offered as a 20-gal an hour pump, also with open or explosion-proof motors, and in a variety of voltages.

Circle letter (F) on reply card.

(G) PLUNGER PUMP

A new Triplex plunger pump for water flooding service at pressures up to 2800 psi has been announced by Gardner-Denver Company. The new pump, known as the Gardner-Denver Model PA-8, is rated at 160 hp, and is said to have a maximum capacity of 263 gpm. The pump is fitted with ceramic plungers, and the liquid end available either in steel or bronze.

Circle letter (G) on reply card.

(H) VALVES

The William Powell Company, has announced the addition of a new line of valves that will be of special interest to industry. Known as Powell Ni-Resist valves, they are specifically designed to checkmate the high cost of corrosion. The company has used an alloy with far greater corrosion and heat resistance than ordinary cast iron, James Coombe, president, reports.

Circle letter (H) on reply card.

(I) SHOVEL

As part of a continuous program to serve the needs of a fast moving industry, American Hoist reports that it is now offering an alternate rope crowd front for its Model 375 ¾ yd shovel. The new front features a box section type boom with large diameter boom point sheaves and wide cast steel boom foot. The single rigid dipper stick has proved itself ideal in heavy, rugged digging.

Circle letter (I) on reply card.

(J) LINE MARKER

A new safety line marker for industrial application, Model 1-10, has been announced by M-B Corporation. Hand-propelled, this pressure type marker has a 10-gal paint tank and marks single lines 2½, to 5 in. in width, and up to 8000 ft per hour of 4 in. line. Its 1 hp air-cooled engine uses a gallon of gasoline per day.

Circle letter (J) on reply card.

(K) GENERATORS, DETECTORS

The CSG-2 cable signal generator and CFD-2 cable fault detector manufactured by Southwestern Industrial Electronics, are claimed to locate cable failures rapidly

and economically. This system offers flexibility required for trouble shooting multiple take-out cables. Self-powered, units are contained in aluminum cases with water-tight covers. Generator unit has a recepticle for cable plug, and external binding posts. Detector unit has light-weight headphone and cable probe.

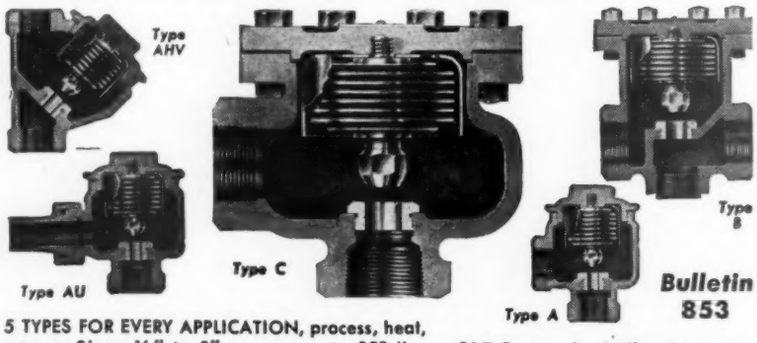
Circle letter (K) on reply card.

In This Plant Nicholson Traps

SAVED 10% IN STEAM COSTS

Chief Engineer H.F.D. stated, after Nicholsons replaced mechanical traps in his plant: "Saving in steam waste cut our fuel cost at least 10%. Yet application temperatures were up 30°-40°. And relief of all air binding effected faster warm-up."

Operate on lowest temperature differential; 2 to 6 times average drainage capacity; maximum air venting. For other advanced Nicholson features send for Bulletin 853.



Bulletin 853

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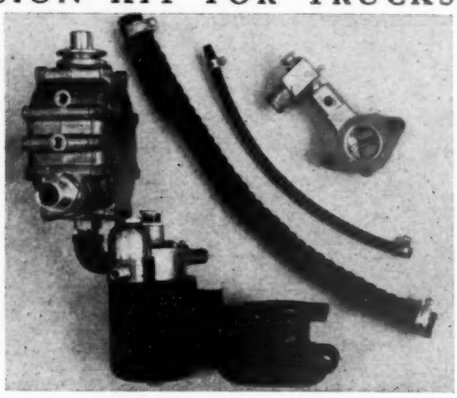

GMC and Chevrolet Kit

SANDWICH type adapter slips into middle of carburetor, affording *QUICK, EASY* conversion to gas-gasoline operation.

SPECIAL CASTING houses thermostat and LP-Gas vaporizer, and supports complete unit, on front of engine block.

- NO MOUNTING HOLES TO DRILL
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"Twenty Years in Gas Carburetion"

New Equipment

(L) WATER SEPARATOR

A successful water separator has been announced by Warner Lewis Company, Division of Fram Corporation. Named the Excel-So, it is designed to remove entrained water from light hydrocarbon products. The separator employs a treated wood fibre packing. The packing is preferentially wet and water particles are coalesced into large droplets that settle rapidly. This permits high water removal, high product flow rate, and short residence time of the product in the separator drum.

In order to obtain optimum flow conditions and minimize pressure loses, much of the separator piping is fabricated with Tube-Turn welding fittings. They are also said to eliminate leakage and excessive maintenance overhead.

Circle letter (L) on reply card.

(M) RODLESS PUMP

Sargent Engineering Corporation has introduced a hydraulically operated downhole pumping unit. The Sargent rodless pump consists essentially of a standard production pump coupled to and driven by a hydraulic engine valve. The unit is energized by crude oil under pressure that is provided by any suitable prime mover at the surface. It permits installation of a power unit having a maximum lift area in production tubing of a given internal diameter.

Circle letter (M) on reply card.

(N) DIESEL ENGINES

Harnischfeger Corporation is now in production with a complete improved line of 2-cycle diesel engines featuring 36 per cent greater power output, the company reports. While the same basic design as the former models, the new engines carry 52 advancements. They feature simplicity of design and construction. Operating speed has been increased to 1800 rpm. Compression ratio of all models is 16 to 1 and bore and stroke are 4.5 by 5.5 in.

Circle letter (N) on reply card.

(O) PLASTIC

Phillips Petroleum Company has developed a new type polyethylene plastic, that can be produced by a process requiring a lower investment than existing processes, according to the company. A semi-commercial plant to make this new plastic will be built at Adams Terminal on the Houston Ship Channel. The new plastic is said to improve such products as film-type wrapping for vegetables and fruits, plastic tubing, and coated paper. It also opens up new uses for polyethylene, such as nonbreakable baby bottles, and other vessels that must be steam-sterilized.

Circle letter (O) on reply card.

(P) SYNTHETIC RUBBER

A new synthetic rubber, a KEL-F fluorocarbon elastomer, which has properties reportedly not found in other rubber products, has been developed by cooperative research by the Office of the Quartermaster General, Department of the Army, and The M. W. Kellogg Company. Unique feature of this rubber is its unusual resistance to corrosive chemicals. It is resistant to strong acids such as fuming nitric and sulfuric acids, and is also unaffected by hydrocarbon fuels and lubricants, oxygen, ozone, and sunlight.

Circle letter (P) on reply card.

(Q) PIPE COUPLINGS

Grooved-end gate valves in the 225 lb W.O.G. "King-clip" and 200 lb W.O.G. iron body bronze mounted patterns for users of grooved-end pipe couplings have been added to the line of valves manufactured by The Lunkenheimer Company. Lunkenheimer is manufacturing iron body bronze mounted gate valves with grooved ends in 2½, 3, 4, 6, and 8 in. sizes. Grooved-end valves have been proved readily adaptable in various piping installations.

Circle letter (Q) on reply card.

(R) PUMP OIL

A new diffusion pump oil called Cencoil-B for use in diffusion and fractionating pumps has been developed by Central Scientific Company's engineers. The new oil, which is a highly purified, distilled-in-glass, di-2-ethyl hexylphthalate, when used in a single stage, non-fractionating diffusion pump produces a vacuum of the order of 7×10^{-6} mm (Hg) at 25 C without the use of a liquid air or charcoal trap.

Circle letter (R) on reply card.

(S) SIDE BOOM

A new side boom for a crawler tractor with a 38,000 lb lifting capacity at 4 ft overhang is announced by Tractomotive Corporation. It is the Model TSB-9 for the Allis-Chalmers HD-9F tractor, 72 drawbar horsepower. It is expected to fill the requirements of many pipe line contractors working with small diameter feeder and distribution lines. It will also serve in the oil fields and at refineries for general maintenance work, as well as on actual pipe line construction. This unit is mounted on the Allis-Chalmers HD-9F crawler tractor and joins its two larger companion machines already in the field, the TSB-15 and TSB-20 side booms.

Circle letter (S) on reply card.

(T) ROD PACKINGS

Two new mechanical rod packings have been developed by the mechanical packing division of the Flexrock Company, using a new lubricant and impregnation process for handling non-water soluble solvents, such as benzene, carbon tetrachloride, xylene, turpentine, kerosine, gasoline, and Stoddard solvents. Style No. 181 has a square braided rayon base, and is recommended for pumps, valves and fittings, handling such chemicals at temperatures up to 200 F.

Circle letter (T) on reply card.

(U) TIRE VALVE CAPS

Plastic tire valve caps in varied colors designed to match colors of automobiles, were introduced at the recent Packaging Exposition at Atlantic City by Owens-Illinois Glass Company. Manufactured by the closure and plastics division of Owens-Illinois, the valve caps are available in a broad range of colors.

Circle letter (U) on reply card.

(V) PIPE FINDER

A new pipe finder is announced by Fisher Research Laboratory. This new electronic instrument features improved operational and overall field performance for locating and tracing buried pipes, conduits, and metal objects. the company reports. Instrument cabinets are red moulded fiberglass. New material is impervious to water.

Circle letter (V) on reply card.

(W) OVERLOAD PROTECTION

A new line of compact, adjustable torque-limiting overload protection devices for a wide variety of machine drives is now available from Morse Chain Company. Called Morse torque limiters, these slip-type friction clutch devices feature a powdered metal bushing on which such drive components as chain sprockets, V-belt pulleys or gears can be mounted. Eleven standard models giving maximum torque capacities from 20 to 620 ft-lb can be had.

Circle letter (W) on reply card.

(X) NICKEL CLADDING

Production of nickel clad steel plate through the electro-deposition of pure nickel on mild steel plates ranging in thickness from ⅛ to ¾ in., with the cladding on either or both sides, has been announced by Bart Manufacturing Corporation. The electrodeposited nickel gives a tenaciously bonded, ductile, and pore-free cladding up to .020 in. thick or more. Plates are made in sizes up to 8 by 20 ft.

Circle letter (X) on reply card.

(Y) COATING DEVICE

Roskoter, a new pipe line coating device, designed specifically for application of Roskote cold-applied mastic, has been introduced by Royston Laboratories, Inc. The Roskoter is a hollow cylinder that can be fitted around any size pipe up to 12 in. Interchangeable coating shoes lined with special, heavy-duty carpets are secured to each end of this cylinder. Adjustable draw-bands control film thickness.

Circle letter (Y) on reply card.

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...for PIPELINES, REFINERIES, GASOLINE PLANTS
This ruggedly built instrument of laboratory accuracy is ideal for quick checking and for continuous recording of Specific Gravity of liquids under line pressure. Changes in Specific Gravity of sample are recorded with a very minimum of time lag. Foreign liquids and gases are automatically purged from sample. No moving joints or stuffing boxes to cause friction or leakage. Temperature corrected, this precision instrument is adaptable to high pressures. Hundreds are in daily use in plants and refineries of major companies. Also available as a controlling instrument. Send for bulletin No. 111A.
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(Z) TIPS, ADAPTER SHANKS

The resistance welding division of Ampco Metal, Inc., has announced the new addition of "Recap" tips and adapter shanks to the product lines of Ampco-Weld for immediate off the shelf delivery. In addition to providing a double water seal and being made out of high conductivity alloys, other advantages include: Welding face of the tip can be ejected without removing the entire electrode, electrode cost is reduced in numerous applications, and many others.

Circle letter (Z) on reply card.

(AA) VERTICAL TURBINES

The Dean Hill Pump Company announces new improvements in the entire DH vertical turbine line. A major change was the addition of a steam nozzle to all models. As a result Models DH-10V (new in vertical line) and DH-20V have 100 per cent more power than former one-nozzle counterparts. Model RH-30V now has three steam nozzles — and 50 per cent more power.

Circle letter (AA) on reply card.

(AB) DIPPER TRIP

The Schield Bantam Company has announced addition of an electrically operated shovel dipper trip as optional equipment on the company's line of truck and crawler-mounted ⅜-cu yd power shovels. New trip attachment enables operator to swing and dump without changing controls. A thumb-operated push-button switch is mounted on the swing clutch lever, which activates an electric motor mounted on the shovel boom.

Circle letter (AB) on reply card.

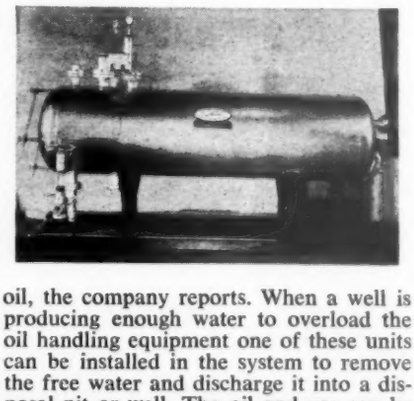
(AC) SHOVEL

After a full two years of research and engineering plus another year of field testing, American Hoist announces it has its new Model 750 shovel in full production. The new shovel is rigged for all purpose work — crane, clamshell, dragline, shovel and backhoe. As a shovel, the machine is rated at 1½ yd with backhoe designed for the same capacity. Thirty-five tons is the machine's rated capacity as a crane, and it will handle a two yard clamshell or dragline.

Circle letter (AC) on reply card.

(AD) WATER KNOCKOUTS

The Model 36WK-0212S free water knockout now being produced by Oil Metering and Processing Equipment Corporation will remove free water from crude



oil, the company reports. When a well is producing enough water to overload the oil handling equipment one of these units can be installed in the system to remove the free water and discharge it into a disposal pit or well. The oil and gas can be discharged from the unit separately or together as desired.

Circle letter (AD) on reply card.

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CHEMICAL
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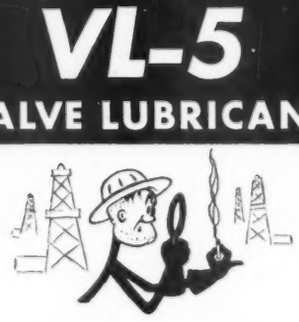

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JET-LUBE VL-5 is a low friction, valve lubricant with micro-ground moly-disulphide. Ends "sticking" valve problems. High temperature. No melting point. Insoluble in hydro-carbon solvents, water, brine, sulphur, acids and alkalies. Batch controlled. Fully guaranteed.

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Trade Literature

Publication will be sent free.

(AE) SPECIALIZED TOOLS

McCullough Tool Company has just issued a new 40-page, illustrated general catalog. This 1954-55 catalog contains a complete description of the entire line of specialized tools and services available through the company. It gives explanation of sizes, applications, operation, and recent improvements. An expanded section gives latest information on McCullough radiation well logging service with the new radiation counter (Scintillometer).

Circle letter (AE) on reply card.

(AF) LINE CASING

Spang extreme line casing is the subject of Bulletin 400-A (12 pages), announced by Spang-Chalfant, Division of The National Supply Company. Advantages of its integral joint design are illustrated in color. The bulletin shows depth recommendations for three grades and clearance advantages for eight sizes.

Circle letter (AF) on reply card.

(AG) V-BELTS

A new eight-page V-belt catalog has been published by The B. F. Goodrich Industrial Products Division. BFG patented Grommet belts in standard and high capacity constructions are featured. New horsepower rating tables permit the design or re-design of V-belt drives at reduced cost. Drawings are included.

Circle letter (AG) on reply card.

(AH) MODERN EQUIPMENT

The story of man's "gravitation through the ages toward superior mechanisms" is portrayed in the new issue of "Production Road" magazine, released by Twin Disc Clutch Company. Other features are articles on trend toward modern portable aggregates plants; adaptability of torque converters; solutions of power linkage problems through fluid drives, etc.

Circle letter (AH) on reply card.

(AI) METERS

Bulletin 105A, published by Associated Research, Inc., describes construction, operation, and application of Model 243A soil resistivity meter, the only instrument believed currently available with a scale calibrated to read directly soil resistivity up to 30,000 ohm-cm. The bulletin consists of two pages in black and white.

Circle letter (AI) on reply card.

(AJ) JOB PHOTOGRAPHS

"A Photographer's Guide for Loraine Equipment" is title of a new folder published by The Thew Shovel Company. Folder was prepared for use when writing photographers regarding assignments for job photographs of Loraine equipments. Inasmuch as it contains information that would be applicable to photographers of any construction equipment, it is available to the public.

Circle letter (AJ) on reply card.

(AK) ALLOY WELDING

The "Tentative Specifictions for Copper and Copper-Alloy Welding Electrodes" ASTM Designation B 225-53T, AWS Designation A 5.6-53T has recently been revised and released in printed form for general use, by Ampro Metal, Inc. Specification covers chemical requirements, deposit mechanical properties, methods of testing, preheat and interpass temperatures, sizes, etc. for copper and copper-alloy electrodes for metal-arc, and inert-gas consumable electrodes processes.

Circle letter (AK) on reply card.

(AL) SHOVELS, CRANES

American Hoist and Derrick Company, offers a descriptive catalog on its new 1-½ yd shovel, 35-ton crane. The new American 750 includes many exclusive features that save both time and money on any job. Action pictures of the machine in quarries and gravel plants and handling pulpwood are included.

Circle letter (AL) on reply card.

(AM) GASES, LIQUIDS

In new, illustrated descriptive bulletins, American Recording Chart Company offers full details concerning its line of gravity measuring devices. Specific gravity instruments for use with liquids are covered in Arcco Bulletin No. 111-R2. Bulletin No. 101-R2 covers instruments for the measurement of specific gravity of gases.

Circle letter (AM) on reply card.

(AN) PUMPS

A new technical paper No. 62 (reprint of an article that was published in January 1954) explains what controlled volume pumps are, how they work, and how they are used as flow control instruments in typical refinery applications. Included are systems on pH control, fuel oil treating, crude desalting, and sampling.

Circle letter (AN) on reply card.

(AO) FINISHES

Descriptions and technical data on new high-heat resisting finishes for temperatures as high as 1600 F are contained in a new four-page, two-color bulletin released by General Paint Corporation. Physical properties, various applications, and economic advantages of special finishes for hot metal surfaces are given, along with application directions.

Circle letter (AO) on reply card.

(AP) FIRE PROTECTION

The automatic sprinkler department of Blaw-Knox Company has published an eight page bulletin, No. 2426, entitled, "Fire Can Destroy Your Business." Bulletin points out that 43 per cent of firms whose records are lost in fires never reopen and an additional 28 per cent quit business within three years. Outlining advantages of Blaw-Knox automatic fire protection systems, the bulletin claims 50 to 90 per cent reduction in fire insurance costs due to the installation of a Blaw-Knox system will pay the cost of installation in 5 to 10 years.

Circle letter (AP) on reply card.

Heavy Duty Wheel and Roller

★ Positive clean-cutting action.
★ Hooks on pipe easily . . . tracks perfectly . . . sturdy malleable frame formed to fit the hand and guaranteed warp-proof.
★ High alloy steel cutter wheels leave practically no burr.
★ Rollers in hook provide a square base when starting tool on pipe. Cuts ⅛" to 2" pipe . . . with speed and ease! Order through your supply house. Write for new catalog. The Toledo Pipe Threading Machine Co., Toledo, Ohio. New York Office: 165 Broadway, Room 1310.

RELY ON THE LEADER!

TOLEDO

POWER PIPE MACHINES
POWER DRIVES
PIPE TOOLS

To obtain more information on products advertised see page E-57

EASY DOES IT

Easy is the word for Naylor light-weight pipe in oil field operations. It's easy to handle. It's easy to transport. It's easy to install—even over rough terrain. That's one reason why field crews like to work with this distinctive lockseamed spiral-welded pipe.

Write for Bulletin No. 507.

NAYLOR PIPE

Naylor Pipe Company . 1240 East 92nd Street, Chicago 19, Illinois

Eastern U.S. and Foreign Sales Office: 350 Madison Avenue, New York 17, New York

Exclusive Distributors in Mid-Continent and Gulf Coast Areas

Mid-Continent Supply Company, Fort Worth, Texas and Branches

Trade Literature

(AQ) METER RUN DESIGNS

In its complete catalog published to date by Robinson Orifice Fitting Company, will be found considerable engineering data relating to meter run designs, the company reports. It is complete with graphs, charts, and curves showing recommended orifice fitting installation and piping arrangements. Catalog carries many tables useful to men concerned with orifice fitting application.

Circle letter (AQ) on reply card.

(AR) TRANSMISSION LINES

Prodelin, Inc., has published a 20-page bulletin entitled "Coaxial Transmission Lines and Wave Guide." Prodelin Series 800, 600, and 200 broadband coaxial transmission lines have extensive applications to 3000 mc without regard to frequency. All can be supplied with couplings for rapid, leak proof assembly in the field, the bulletin reports. Series 600 incorporates pin type Teflon insulators. Bulletin is illustrated.

Circle letter (AR) on reply card.

(AS) SUCKER ROD GUIDE

Fluid Packed Pump Company has published an interesting report on sucker rod guides. Completely described is the Oilmaster sucker rod guide, which the company claims has proved effective in reducing friction and eliminating damaging effects of wear in the rod and tubing strings. Annual clearance and slots provide ample fluid passage. Slots are cut diagonally so that bearing areas overlap one another.

Circle letter (AS) on reply card.

(AT) GAS-OIL BURNERS

Combination oil and gas burners for industrial applications are described in a new bulletin issued by The Engineer Company. Alternate arrangements are shown including: Air registers convertible from one fuel to the other, those that permit firing with either or both fuels without changing burners — and with either standard-range or wide-range oil burners, and either natural or waste gas.

Circle letter (AT) on reply card.

(AU) HAMMER, COATING

The Gustanite Corporation has published two leaflets, one on its Flex-Flo safety hammer and one on its new product Slipruf, a secure grip coating for tool handles, valve, etc. The hammer is said to feature an analytically-controlled copper-base alloy. Corrugated construction that provides controlled compression, keeps the hammer from mushrooming. Products are handled by Armite Company.

Circle letter (AU) on reply card.

(AV) CAPACITY DATA

In order to provide more complete and accurate data for users of 4-wheel, pneumatic-tired, tractor-shovel equipment and to clarify some confusion resulting from the absence of standardization of capacity listings, The Frank G. Hough Company, has just announced that both the "struck-load" and "pay-load" capacities are being provided for all models of the "Payloader" line. Decision to provide these new listings is the result of a survey that indicated users are often faced with the difficulty of making comparisons between various types of machines where both capacities are not given.

Circle letter (AV) on reply card.

(AW) PUMPS

Worthington Corporation offers a new bulletin, graphically illustrated with application photographs, on oil field and pipe line equipment. The bulletin contains specification information on many types of pumps, including those for water flooding; steam turbines and turbine-generators; oil, gas and dual fuel engines; "packaged" oil field compressors; various types of air and gas compressors, etc.

Circle letter (AW) on reply card.

(AX) CLEANING PROBLEMS

Oakite Products March-April publication of Oakite News Service is now available. Featured in the new issue are "Care and Feeding of Air Conditioning Equipment," "How Cleaning Aids Fleet Maintenance," "A Business Grows in New England," and "Boating for Fun."

Circle letter (AX) on reply card.

(AY) JACKETED VALVES

Jerguson Gage and Valve Company has published new literature on its jacketed valves Nos. 93 and 93U. New data Units 220 and 221 describe operational features on Jerguson jacketed valves for heated-cooled gages or wherever small jacketed angle valves are required. Full specifications are included, and cut-away views show internal construction.

Circle letter (AY) on reply card.

(AZ) STANDBY PLANTS

A new folder, describing the complete line on Onan Standby electric plants which has been awarded the Certificate of Approval by the Industrial Board of the Pennsylvania Department of Labor and Industry, has been released by D. W. Onan & Sons Inc. The four-panel, two-color folder describes wide selection of special emergency electric generating plants.

Circle letter (AZ) on reply card.

(BA) COKE HANDLING

Sauerman Bros., Inc., have published a completely illustrated bulletin that describes coke handling and storage at the Standard Oil (Indiana) and Pan-Am Southern plants. Numerous photographs illustrate the different plants, along with reading material to make the descriptions complete.

Cidcle letter (BA) on reply card.

(BB) WATER-FLOOD METER

The Neptune water-flood meter, for accurately measuring water injected underground in oilfield secondary recovery operations, is illustrated and described in new Neptune Meter Company bulletin No. 559. Made of special alloys to withstand corrosive effects of waters containing minerals and salts, meters handle pressures to 2000 psi, and is accurate at rates of flow between 3 and 28 bbl per hour.

Circle letter (BB) on reply card.

(BC) TURBINES

The whole new line of D-H turbines is described in a new catalog, No. 500, now offered by Dean Hill Pump Company. This flexible covered, 16-page publication provides complete data on the improved D-H horizontal and vertical turbines. Major change in turbines was addition of one more steam nozzle and one additional (optional) handvalve to all models.

Circle letter (BC) on reply card.

Wanta pump something at lower cost?

CHECK HERE

Air	Dye Solutions	Latex	Salt Water
Alcohol	Edible Oils	Mash	Shortening
Ammonia	Ethane	Methane	Sludge
Beer	Fish Oils	Milk	Soap
Benzol	Formaldehyde	Molasses	Sodium Chloride Solution
Boiler Feed Water	Fresh Water	Naptha	Sodium Silicate
Brewer's Mash	Gas, Manufactured	Nitric Acid	Sodium Sulfate Solution
Butter	Gas, Natural	Nitrogen	Starch
Butane	Gasoline	Oil, Crude	Sulphuric Acid
Cane Syrup	Glucose	Oil, Refined	Sump Water
Calcium Carbonate Slurry	Glue	Oxygen	Sweet Water
Calcium Sulfate Slurry	Glycerine	Paint	Tomato Juice
Casein Solutions	Glycols	Potassium Hydroxide	Varnish
Cement Slurry	Hydrochloric Acid	Propane	Vinegar
Chocolate	Hydrofluoric Acid	Raw Boiler Feed Water	Viscose
CO_2 Gas	Ink	River Water—Dredging Operations	Water (various)
Crude Oil	Jam	Rosin	Wax
Dairy Products	Jelly		Whey
	Ketchup		
	Lacquer		

THIS list of fluids will give you a rough idea of the diversity of pumping jobs in which Darcova Pumcups are responsible for really *big* savings.

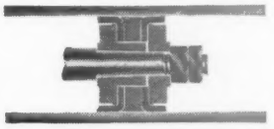
It boils down to the fact that Pumcups all but eliminate fluid slippage *throughout* their life span . . . and they *last many times as long as other packings.* Think of the down-time avoided, the production gains due to prolonged high efficiency, and the time-and-money-saving reduction in maintenance!

Years of application research have gone into the development of Pumcups. Made today in standard as well as many special compositions and textures for a wide range of temperature and pressure conditions, they offer you superior cost-cutting service in virtually *any* pumping job, simple or tough! And they're available in diameters from 1 to 20 inches.

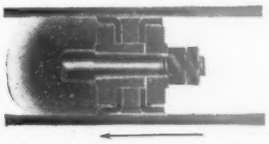
SEND FOR FREE BULLETIN

Why not weigh *all* the facts? Bulletin 4401 covers Darcova Pumcups for reciprocating pumps; Bulletin 4502 on Pumcups for air or hydraulic mechanisms. Write for yours today.

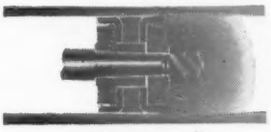
DIAGRAM OF DARCOVA PUMCUP ACTION (greatly exaggerated)



NORMAL: BOTH PUMCUPS RELAXED



UNDER PRESSURE: PUMCUPS SEAL AGAINST CYLINDER DESPITE WEAR, MINIMIZING SLIPPAGE



DARLING VALVE & MANUFACTURING CO.
WILLIAMSPORT 2, PA.

DARCOVA
THE ORIGINAL COMPOSITION CUP
PUMCUPS

ARMCO

Spiral Welded Casing

Seven carloads of Armco Casing delivered to a major oil company in Texas.

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New Iberia, La.
Odessa, Texas
Oklahoma City, Okla.
Pampa, Texas
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Seminole, Okla.
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- EXACT 40' LENGTHS
- HIGH COLLAPSE RESISTANCE
- UNIFORM WALL THICKNESS
- FAST RUNNING TIME
- SAVES TONNAGE
- SAVES MONEY

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